THE PEDAGOGY OF ARCHITECTURAL STRUCTURES IN SELECTED UNIVERSITIES IN SOUTHWEST, NIGERIA

By

ALALADE, GBENGA MARTINS
B.Sc. Architecture
M.Sc. Architecture
Matric. Number: CU02310008

A THESIS SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE, COLLEGE OF SCIENCE AND TECHNOLOGY, COVENANT UNIVERSITY, OTA, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF Ph.D. DEGREE IN ARCHITECTURE,

MAY, 2017

ACCEPTANCE

This is to attest that this thesis is accepted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy (Ph.D.) in Architecture, College of Science and Technology, Covenant University, Ota.

Mr. Philip John Ainwokhai ....
Secretary, School of Postgraduate Studies Signature & Date

Prof. Samuel T. Wara ....
Dean, School of Postgraduate Studies Signature & Date

DECLARATION

I, Alalade, Gbenga Martins, declare that this thesis was carried out entirely by me under the supervision of Dr. E.O. Ibem (Supervisor) and Prof. E.A. Adeyemi (Co-Supervisor) both of the Department of Architecture, Covenant University, Ota, Ogun State. The thesis has not been presented, either wholly or partly, for any degree elsewhere before. All sources of scholarly information used in this thesis were duly acknowledged.

ALALADE, Gbenga Martins ....

Signature & Date

CERTIFICATION

This thesis entitled "The Pedagogy of Architectural Structures in selected universities in Southwest, Nigeria" carried out by Alalade, Gbenga Martins under my supervision meets the regulations governing the award of the degree of Doctor of Philosophy (Ph.D.) in Architecture of the Covenant University, Ota, Ogun State, Nigeria. I certify that it has not been submitted in part or full for the award of the degree of Ph.D. or any other degree in this or any other university, and is approved for its contribution to knowledge and literary presentation.

Dr. Eziyi O. Ibem --
Supervisor Signature & Date

Prof. Ekundayo A. Adeyemi --
Co-Supervisor Signature & Date

Dr. Oluwole A. Alagbe --
Head of Department Signature & Date

Prof. Samuel A. Daramola --
External Examiner Signature & Date

Prof. Samuel T. Wara …………………………………..
Dean, School of Postgraduate Studies Signature & Date

DEDICATION

……to the all-wise God, the all-knowing God, the giver of wisdom and insight for His gift of wisdom and knowledge to me expressed in this work.

My wife, Morenike

My Children, Akinpade and Akindeji

My Parents

Late Michael Alalade and Olufunke Alalade

ACKNOWLEDGEMENTS

My profound gratitude goes first to God, the all wise, the all-knowing for the gift of wisdom and insight. I appreciate the Chancellor- Dr. David Oyedepo for his aggressive drive for capacity building. I appreciate the Management of Covenant University, led by Prof.A.A.A. Atayero for the sponsorship of this Ph.D. work. I would like to appreciate my supervisor, Dr. E.O. Ibem. It has been a great honour to be his first Ph.D. student. His insightful guidance and thoroughness deeply enriched this work. I am also thankful for the foresight and wealth of experience my co-supervisor, Prof. E.A. Adeyemi.

The sacrifices my wife, Morenike Alalade made at the home front enabled me to focus on this work. My two sons, Akinpade and Akindeji, endured my many nights out to study. The priceless legacy of education my parents, Late Michael Alalade and Olufunke Alalade, bequeathed to me and my siblings was the foundation that culminated in this academic pursuit. Posterity will reward you and I will strive to always make you proud. My siblings, Bola, Segun, Femi, Lanre, Yomi and Kunle continuously followed up till the completion of this work.

Dr. A.A. Oluwatayo (my unofficial co-supervisor), provided immense assistance on data analysis with SPSS. Her contribution was a critical prop for this work. My indefatiguable research assistants, Enahoro Udugbezi (my super assistant), Opeyemi Job, Gbenga Durand, Rotimi Komolafe and David Idibe assisted with field work.

The faculty in the department of architecture provided a fertile environment for intellectual discourse through monthly research seminars, and one to one chats in the offices, corridors e.t.c. Dr. O.A. Alagbe (my first academic mentor), Prof. A.B.Adeboye (the erstwhile head of department), Dr. P.A. Aderonmu (a model of pedagogy), Arc.U.O.Uwakonye, Dr.E.B. Aduwo, Dr. I.C. Ezenma, Dr.A.P. Okpoko, Dr.O. Dare-Abel, Dr.O.N.E. Ekhaese, Dr.D.O. Babalola, Dr. O.J. Ediae, Dr.B.A Adewale, Dr.O. Izobo-Martins, Arc.O.Fulani, Arc.F.Jegede and Arc. A. Owoseni, thank you for your varied inputs in this work.

Prof. O.O. Amole (Obafemi Awolowo University) gave this work the initial push by believing in it even at its nascent stage. Dr.C.O. Adeokun, provided relevant resource materials. My students, provided a virile ground to experiment some of the concepts explored in this work, I am grateful.

My covenant friends, Dr. Muyiwa Oludayo and Azubuike Ezenwoke that made up the three musketeers never stopped following up on this work. Thank you. Dr. Nkiko, erstwhile Director, Centre for Learning Resources, Covenant University, and Mrs. Ilogho, assisted with several publications. To a host of others too numerous to mention, thank you.

TABLE OF CONTENTS

CHAPTER FIVE: DISCUSSION

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

ABSTRACT

The general perception of structures by architects and students suggests that there is a need for a rethink on the approaches to the teaching and learning of the course in the schools of architecture. Therefore this study investigated the teaching and learning of architectural structures in four universities in Southwest, Nigeria, with a view to identifying ways of improving students' interest and understanding of the course. Survey research strategy involving random sampling techniques was used in selecting 288 students and faculty. The data collection instruments were structured questionnaire and interview guide. Data obtained were analysed using descriptive and inferential statistics. The data from the interview were analysed using content analysis. The result shows that the current traditional sequence of the structures curriculum was isolated from the architectural design process. It was also found that the teaching approaches placed more emphasis on structural analyses that promote structural literacy than on structural behaviour, which engenders structural competence. Further, it was observed that the use of Information and Communication Technologies (ICTs) in the teaching and learning of structures was low in the four universities sampled. The regression model revealed that students' perception of curriculum content (β=0.307), level of interest (β =0.271), visual based instruction (β =0.164), relevance of structures to design studio (β =0.156), learning style (β =0.155) and personality characteristics (β =0.136) emerged as the strongest predictors of the learning outcomes in structures. This implies that optimum learning in structures is contingent on an instructional strategy built around these six predictors. The findings also imply that for a better understanding of structural behaviour, there is a need for curriculum review with emphasis on design studio-oriented approach and adoption of digital technologies in the teaching of structures. In addition, the study implies that the adoption of visuo-spatial thinking and visual communication strategies in contrast to mathematical thinking and numeric communication strategies currently in use in teaching structures in the study area is critical to improving and sustaining architecture students' interest in and understanding of structures as a course.

Keywords: Architectural design, Architectural structures, Learning Outcomes, Architecture Students Survey, Curriculum

CHAPTER ONE

INTRODUCTION

1.0 Background to the Study

The architectural design process involves the creative integration of appropriate technology. This requires consultation with engineers and good judgment by architects regarding interdisciplinary aspects. Thus, informed intuition about technology is essential for architects, just as musical instruments to conductors (Schierle, 1997). The ever-evolving role of the architect, from medieval to contemporary times is pivoted on leadership as it is expected that he/she be versatile in the different disciplines that relate to a building.

The architect's duty entails protecting a building and its occupants from rain, ensuring the site is properly drained, thermal comfort, visual comfort, space planning, fire protection, client relations, contract law and project management. Others include functionality and integrating building in the larger cultural context, security, economy, compliance to codes and standards, and making a building resist all the forces to which it will possibly be subjected to. This last role is encapsulated in the subject area known as architectural structures (Place, 2007).

Essentially, architectural structures is the support system (skeleton) of buildings with respect to its external and internal environment. The external environment encompasses the forces acting on the building (including imposed loads such as wind load, snow load, live loads and self-weight), while the internal environment are the reactions taking place within the building as a result of the impact of the external environment and human activities on the building. Architecture history, from Vitruvius to Frank Lloyd Wright leaves indelible imprints of the significance of structure in the great buildings of the Masters. The legendary Frank Lloyd Wright stated, "it is pretty hard to take the word 'structure' apart…." However, he also noted that, “Form is the inevitable result of structure”. Architectural theorists have also come to a consensus that structure is a generator of form.

In an attempt to underscore the significance of architectural structures, it is pertinent to note that it is a subset of architectural technology, which can be viewed as the other side of architectural design in the entire gamut of architecture as a process and a product. On a broader scale, architecture can be seen as a coin with two faces: design and technology. These two are mutually dependent. Central to understanding architecture is the relationship between design and technology (Silver and Maclean, 2008). This implies that if there must be good architecture, one cannot exist without the other, that is design cannot exist without technology and vice-versa. However, as much as this should be the ideal, the subsisting reality in the built environment, which is essentially a reflection of what goes on in the academia (various schools of architecture) is a marked schism between design and technology.

The idea that architecture (design) belongs to one place and technology in another is comparatively new in history and has a crippling effect on architecture (Banham, 1984). The crippling impact of the design-technology schism has led architecture to the brink of irrelevance as observed by Peters (1992). Peters (1992) noted that we have split off all professional content that relates to building what we design, thus we train students who become excellent thinkers and talkers, wonderful draftsmen and form makers, but with little preparation to build. Consequent upon this, the bulk of what used to be architectural work is now performed by a range of contractors. We have rescinded our duties while claiming vaguely to be “generalists”, implying that we don’t have to know the details, just the general feeling of a problem. This obvious manifestation of the design-technology schism has its root largely in the pedagogical approaches to architectural technology. Architectural technology essentially revolves around structures, construction and materials and environmental control systems (ECS). Although copious literature, Black and Duff (1994) and Allen (1997) have identified various strategies for the integration of technology and design broadly, few have explored the requisite integrating factors and variables of the varied components (structures, construction and materials and environmental control systems) of architectural technology. In view of the fact that Architectural structures is at the core of architectural technology, delineating parameters for an integrative and responsive instructional model can provide a model or template for providing solutions for the pedagogy of architectural technology.

This thesis is therefore an attempt to investigate the teaching and learning of architectural structures as a course. This is with a view to identify ways of improving students' interest and understanding of the course in selected universities in Southwest, Nigeria. This research can therefore be seen as an attempt to proffer solutions to the challenge of understanding structures. It is hoped that the findings of this study can provide the basis for solving the larger problem of technology teaching (design-technology schism) in architecture. It is also hoped that the findings of this work will have some implications for teaching and learning of architectural structures.

1.1 Statement of the problem

Dytoc (2007) has observed that opening the minds of architecture students poses both a challenge in terms of classroom-culture and communication. As a creative discipline, architecture compels a greater need to expose the students' mind in an attempt to simulate creativity. Structures instruction is a core dimension in which this kind of mind-opening and illumination is pivotal particularly noting the inseparability of structure from architecture.

Although the significance of structures to architecture cannot be overemphasized, the subtleties and perception of structures by architects and students suggest that there is a need for a rethink of the approach to structures instruction. The need to rethink architectural structures had always been inherent in architectural education over the last four to five decades. However, this need became more obvious in 1976, when the Association of Collegiate Schools of Architecture (ACSA) formed an *ad hoc* committee that came up with a memorandum on the growing dissatisfaction with the effectiveness of the teaching of structures in schools of architecture (Black and Duff 1994). Salvadori (1958) had earlier noted that the problem of teaching structures to architects is both a very challenging and interesting one. Improving the approaches to pedagogy is not unique to architecture, however as the technical component of a creative degree programme, developing innovative approaches to the teaching of architectural structures is not only desirable but absolutely necessary (Vassigh, 2001).

There is an emerging consensus that the problem of effectively teaching and integrating structures within an architecture curriculum exist. In support of this position, Vassigh (2001) noted that although understanding structure is central to the education of the architect, architecture faculty and students struggle with an engineering-based approach to structures instruction, which is proving to be ineffective in the classroom. Dytoc (2007) corroborated this view by noting that the low effectivity of the "traditional approach" of a structures class for architects has made evident the need to bridge the gap that exists before developing more unified, "whole-brain" designers can be achieved. The review of literature reveals that several attempts towards developing more unified and well-rounded designers, essential in reducing or eliminating the design-technology schism have been made. Such attempts have led to the development of what has been known as alternative approaches to structures instructions as a departure from the engineering-based traditional approach. Such alternative approaches can be seen as visual thinking strategies (VTS). Employing visually intensive media such as graphics, models, ICT platforms-structural software packages and animations (specifics and details to be explored in review of related literature). Despite the potentials and promise of the alternative approaches, there are myriads of theoretical and practicability issues that need to be addressed as identified in the next paragraphs.

First, is the notion of polarities alluded by Allen (1992). One polarity advocates that a great amount of time is devoted to teaching structural calculations, which are the least important thing about structural design. It promotes the development of structural intuition by emphasizing that students benefit more when they learn real and practicable structural concepts. It argues that "*the emphasis of structures should be teaching students to choose a suitable structural material and system for any building, lay out the system in a manner that integrates properly with the building's form and space, and assign approximate sizes to the structural members*" (Allen,1992:1). It further argues that precise sizing of structural members is mostly the duty of engineers aided by computers in the world of practice, thus architecture students only require knowledge of basic calculations. On the other hand, the other polarity advocates that the mathematical fundamentals of structural design are beautiful and provide an appropriate way of understanding the subtleties of structural behavior and helping students develop an intuition for structural design. This school of thought argues that this approach leads obviously to the understanding of detailed structural design and trains students to communicate with structural engineers in their own language. It advocates that the teaching of a field so precise as structures should not be diluted with rough approximations and fuzzy conceptualizations.

Second, is the notion of acceptability and adoptability. There has been marked slow pace of migration or non-migration of instructors of structures from the traditional approaches to the alternative approaches. This attitude of some instructors may not be far-fetched as expressed in the latter polarity that advocates the necessity of the mathematical underpinnings of structures. However, it is important to note that of the several innovative approaches that have been developed and deployed, very few and almost none have been standardized and codified into a working model.

A documented model known to the researcher is the Finite Element Analysis (FEA) model for teaching structures developed by Black and Duff (1994). Black and Duff (1994) reported a six-year experiment conducted at the University of California using an unconventional teaching approach and advanced structural engineering software to teach structures to architecture students. The Black and Duff (1994) FEA model uses the Finite Element Analysis (FEA) and a revised curriculum that sought to juxtapose the contents of the structures curriculum which is a departure from the classical sequence of presenting the material incrementally. The FEA model is hinged on the assertion that much of the detailed material in broad engineering curriculum is not necessary for architecture students, and thus can be bypassed. Although several scholars have confirmed this assertion, it however lacks an empirical basis. This thesis will attempt to provide an empirical evidence to support or refute this claim as part of its effort to explore the pedagogy of architectural structures. Despite the exhaustiveness of the Black and Duff (1994) FEA model, it has not been widely adopted because of some observed shortcomings. These shortcomings are mainly its non-applicability to all aspects of structures curriculum and its engineering- based nature.

From the foregoing, it is obvious that there is a general problem of effectively teaching structures to architecture students (or low effectivity of the traditional methods of teaching structures) and the non-standardization and codification of the several innovative approaches to structures instruction into a working model. This study is therefore an attempt at identifying parameters for an instructional model with the potential of effectively teaching structures and codifying or standardizing the several innovative approaches into a working model. It sought to examine the various innovative and unconventional approaches to structures instructions and attempted to identify parameters for codifying and standardizing them into a working model. To adequately address the general problem of effectively teaching structures, this study examined the existing traditional approaches to structures instruction.

In order to guide the course of this study, the following research questions were formulated:

i. What is the content of the curriculum of structures in the selected universities?
ii. What are the teaching approaches of architectural structures and students' perceptions of the approaches?
iii. To what extent does students' profile influence learning outcomes in structures?
iv. What is the impact of technology (ICTs) on the teaching of architectural structures?
v. To what extent does the learning inputs, students' profiles and the learning environment impact on the learning outcomes of structures in the selected schools?

1.2 Aim of Study

The aim of this study was to investigate the teaching and learning of architectural structures as a course. This is with a view to identifying ways of improving students' interest and understanding of the course in selected universities in Southwest, Nigeria.

1.3 Objectives of Study

The specific objectives of this research were to:

1. assess the curriculum of architectural structures in four selected universities in Southwest, Nigeria,

2. examine the approaches to the teaching of architectural structures and students perception of these approaches in the study area,
3. investigate the students' profiles (personality characteristics and learning styles of architecture students) and their influences on learning outcomes in architectural structures in the selected universities,
4. assess the degree of usage of Information Communication Technology and its impact in the teaching and learning of architectural structures in the four universities sampled, and
5. investigate the impact of learning inputs, students' profiles and the learning environment on learning outcomes of structures in the selected universities.

1.4 Justification

Rethinking architectural structures by way of a situational analysis becomes significant for several reasons, particularly, in the light of growing dissatisfaction with the effectiveness of its teaching in schools of architecture (Black and Duff, 1994).

First, Adeyemi (2012) noted that the traditional role of the architect as the leader of the other allied professions is being challenged by other professions. This waning leadership role, according to Peters (1992), is a manifestation of the design-technology schism which has and is leading architecture to the brink of irrelevance. It appears there is an over-specialization of all professional content that relates to building what we design, thus architecture students are better prepared to design than to build. This study is thus justified on the basis that it attempted to identify parameters for a responsive instructional model in architectural structures with the potential to bridge the design-technology schism and consequently inform the training of whole-brain designers with both design and construction competence.

Second, despite the development of several alternative and innovative approaches to structures instruction, the growing dissatisfaction among students is indicative of a gap between intent and action. This gap can be linked to the fact that while there have been several alternative and innovative approaches; there is non-codification and standardization of these existing alternative approaches into a working model. This study therefore attempted to provide a basis for the codification and standardization of the existing alternative approaches into a working model.

Third, the shortcomings of the Finite Element Analysis (FEA) model for teaching structures suggests a need for a review of this model and the need for new attempts at the design and evolution of a new model. Criticisms of the Black and Duff (1994) Finite Element Analysis (FEA) model includes among others that architecture students are applying or using a model that they do not have an understanding of the underlying theory and the relevant assumptions. This criticism asserts that this is irresponsibility on the part of the initiators and users of the model in teaching structures. The researcher also identified another criticism that borders on the fact that the Finite Element Analysis model in itself originated and is purely a tool for engineering analysis. Thus, nullifying the fundamental reason for developing alternative approaches, which was that the traditional instructional approaches, which have proven to be ineffective are engineering based (Vassigh, 2001). This research sought to identify useful parameters for the development of an instructional model that would be responsive to the biases of the architecture profession- including, students' learning preferences, professional needs of architects and teaching preferences of instructors.

Fourth, improvement in the construction industry as it relates to design decisions in the area of structural design and specification of materials (load bearing and non-load bearing) would of a necessity require structural creativity on the part of the architect especially noting the significant role of structure in architecture. It is important to note that these design decisions have significant impacts on the built environment in areas such as aesthetics of the urban scape, budgeting and cost components of project management. Such structural creativity skills which are requisite for structural design are hinged on the nature and content of structures training received by the student. This study therefore attempted to address issues that directly impact on development of structural creativity in architects.

Fifth, recent developments in structural engineering education are indicative of innovations that suggest much needed transformation. As far back as 1996, Allen (1997) noted that an international symposium on conceptual design of structures (that featured leading structural engineers and scholars) resonated a surprising message. This message was that many teachers of structural engineering around the world have enthusiastically appropriated the design studio for their own purposes. Chilton (1997) also noted that structural engineering education must become much more like architectural education in its use of design studio. As interesting and novel as this paradigm shift may be, structures instruction in architectural education has been very redundant in changing from the traditional engineering approaches. This thesis therefore sought to explore the underlying factors of this paradox and identify strategies with the potentials for a paradigm shift in the pedagogy of architectural structures.

Finally, this study is important even as the global education scene continues to experience shifts; pertinent among these is a shift from the current teacher-centric educational system to student-centered learning (SCL). Lucko *et al.*, (2010) underscored the acceptance level of student-centered learning as a highly effective educational approach. Structures instruction being an essential core of architectural education should not be left out particularly, in view of the need to bridge the gap between academic theory and professional practice. This study hopes to situate structures instruction in the context of student-centered learning and address the issue of communicating useful knowledge to students.

1.5 Scope of Study

Although this study is focused on accredited departments of architecture in Nigeria universities, it is restricted to accredited programmes of architecture in universities located in Southwest, Nigeria. A total of 11 departments representing 47.8% of the 23 departments of architecture in Nigeria, have full accreditation status (both undergraduate and post graduate programmes), see Table 3.2. A total of 4 departments of architecture, representing 36.3% of the 11 fully accredited departments of architecture are located in Southwest, Nigeria. These four departments were investigated in this study. They are: the departments of architecture in University of Lagos (UNILAG), Obafemi Awolowo University, Ile-Ife (OAU), Federal University of Technology Akure (FUTA) and Covenant University, Ota (CU). The accreditation status considered for the purpose of this study is that of the Nigerian Institute of Architects/Architects Registration Council of Nigeria (NIA/ARCON). This is considered because these two bodies are the regulatory agencies for the practice of architecture in Nigeria. These departments are also representative of different generations of universities (with respect to the year they were established) in Nigeria.

1.6 Structure of the Thesis

This thesis begins with an introduction in Chapter one that gives an overview of the thesis. The aim and objectives of the study were clearly outlined in this section. The problem this thesis seeks to address and its justification were also identified. Chapter two of this thesis attempted to review relevant literature while chapter three outlined in detail, the methodology adopted for the research. Chapter four is a presentation of results and analysis. The implications of the results are discussed in chapter five under the heading discussion. The thesis concluded in chapter six with conclusion and recommendations of the study findings.

1.7 Definition of Terms

i. **Pedagogy**: the method and practice of teaching, especially as an academic subject or theoretical concept.

ii. **Architectural Structures** : It is the support system (skeleton) of buildings that makes it withstand all the forces to which it will likely be subjected during its lifetime.

iii. **Learning outcome**: is a mixture of knowledge, skills, abilities, attitudes and understanding that an individual will attain as a result of his or her successful engagement in a particular set of educational experiences.

iv. **Structural Competence:** is the ability to use knowledge of structures (knowledge gained in structures classes) to solve design problems or in the design process.

v. **Structural Literacy :** acquisition of the knowledge of structures (possession of structural knowledge).

vi. **Visuo-spatial Thinking:** acquisition and processing of information through the use of images and spatial relations. Visual includes static properties of objects, such as shape, texture, and color, or between objects and reference frames, such as distance and direction. It also includes dynamic properties of objects such as direction, path, and manner of movement.

vii. **Mathematical thinking:** acquisition and processing of information through the use of numbers, symbols and equations**.**

1.8 Chapter Summary

This chapter provided an introductory overview of the essence and scope of the study. The problem of the study was defined against the background of effective teaching of architectural structures, which is a reflection of a larger problem of the design-technology schism that this study addresses. The aim of this study was therefore to investigate the teaching and learning of architectural structures as a course. This is with a view to identifying ways of improving students' interest and understanding of the course in selected universities in Southwest, Nigeria. The importance of the study was based on the need to rescue the architectural profession from the brink of collapse by bridging the design-technology schism by addressing the problem of effectively teaching structures and the non-codification and standardization of existing alternative instructional approaches into a working model. This study was further justified in view of the shortcomings of the Finite Element Analysis (FEA) model which is essentially engineering biased and its inappropriateness in developing structural creativity in students which is critical to improvements in the built environment especially as it relates to design decisions. In consonance with the aim and objectives of this study, the scope of this research was confined to accredited schools of architecture in South-West, Nigeria.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Introduction

The section seeks to explore and present the current state of knowledge on the subject of this study. It attempts to review the literature on architectural education, educational research (learning sciences and technologies) and the teaching of architectural structures. The significance of this chapter lies in its attempt to identify the gaps in literature that this study attempted to fill.

The review commences with an overview of architecture profession. This is followed by a discussion on architectural education with the aim of identifying its varied strands and their relevance to the architecture profession. In addition, the review attempts to situate architectural structures as a critical core in the triad of architectural technology (composed of architectural structures, materials and methods of construction and environmental control systems-ECS), which is the other side of architecture (design being one side). Further, the numerous instructional approaches to architectural structures are presented, followed by the discussion of the relevant theories related to the subject with the aim of grounding the subject within established body of knowledge. This chapter ends with a summary of the gaps in the literature.

2.1 The Architecture Profession: Pedagogy and Practice

Architecture like every other profession veers into two mutually non-exclusive paths i.e. pedagogy and practice. While the practice dimension can be seen as the tip of the iceberg (easily visible and noticeable to all), the pedagogy dimension is usually the crux of the matter, as it is submerged and unnoticed. In the same manner the pedagogy of any profession provides both the theoretical underpinnings (teaching) and continuous intellectual support (research) for its survival. This significant role of pedagogy to professional practice has been the driving force for several research efforts in the learning sciences and technology education. The architectural profession has had its own fair share of these research efforts, which have culminated in various studies in architectural education.

2.1.1 Architectural Education: Design Education and Technology Education

Despite the noble efforts in architectural education, it appears that these efforts have been skewed towards design education and less towards technology education. Architecture as a creative enterprise in the built environment has been defined as "the art and science of designing and building structures, communities, or open areas, in keeping with aesthetic and functional criteria" (Harris, 2006). It achieves its goals via two mutually non-exclusive media namely: design and technology. The great works of architecture from time immemorial and even in contemporary times have been the ones that have creatively and intricately woven the two strands together seamlessly. To that extent, architectural education has a critical obligation to address and train students sufficiently both in design education and technology education.

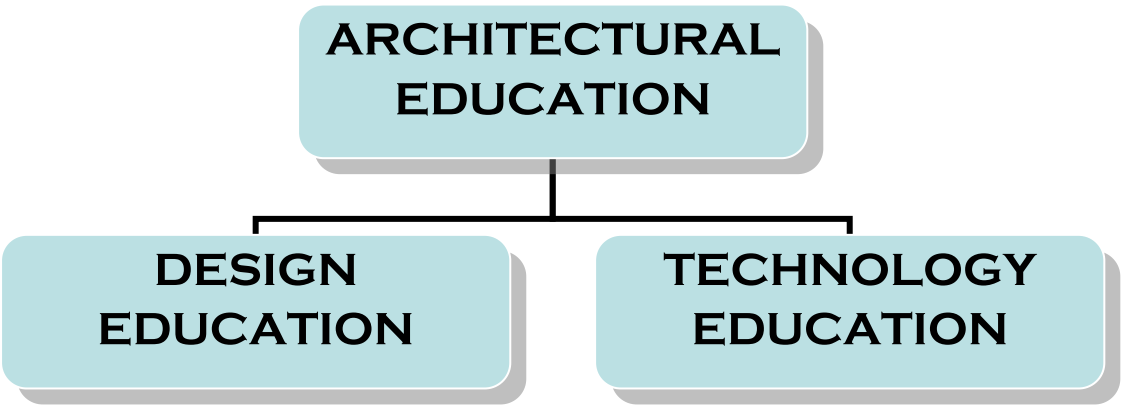

Figure 2.1: Stratification of Architectural Education
Source: Adapted from Connector, (2000)

The study of architectural forms traditionally takes place in the design studio, while the study of the materials and methods of producing those forms has been concentrated in technology courses (Hurtt *et al.*, 1995). From this standpoint, architectural education can be categorized into design education and technology education as shown in figure 2.1.

2.1.2 Design Education

Design as a discipline involves the creating of useful objects for human use, such as structures, illumination and HVAC systems, and acoustical enclosures. Scientifically based calculations and methods (technology) are wonderful ways of checking the adequacy of designs for these objects, but they are analytical only. As Allen (1996) rightly observed, until we teach students to synthesize as well as analyze, we are not doing our jobs.

2.1.3 Technology Education

Technology education in architectural education essentially refers to the teaching of technical content of architectural education. This technical content or technology as earlier noted refers to and revolves around architectural structures, materials and methods of construction and environmental control systems-ECS (which are also referred to as service subjects). The significance of technology education in architectural education cannot be overemphasized. Diamond and Webb (1992) noted that understanding technology is an essential component for effective architectural design. Silver and Mclean (2008) advanced this further by positing that critical to the understanding of architecture is the relationship between design and technology.

Although the significance of technology in architecture is succinctly clear, the existing literature suggests that it appears that there is a gap between technology and design. Haglund

(1993) refers to this gap as earlier noted, as the design-technology schism. Design and technology are meant to co-exist interdependently and integrated into a design solution and not independent as literature suggests. The design-technology schism manifest essentially in the lackadaisical attitudes of students towards technology courses, which is often a reflection of the teaching quality and learning outcome. Architecture students seem to place greater emphasis on the design studio, which has been described as the melting pot of architectural education. The studio culture being advocated and encouraged in almost all schools of architecture globally, appears to have further widened this gap. This is done by subtly demanding that students spend greater time with their designs in the design studio (many times almost all day and all night). Lee (1993) observed that a major challenge in teaching technology within a design-focused architectural curriculum is the assumption that the technologies are of little relevance to the "significant" design issues students encounter. In the face of this design-technology schism, researchers and architectural theorists have made several attempts at bridging this gap and shrinking this schism.

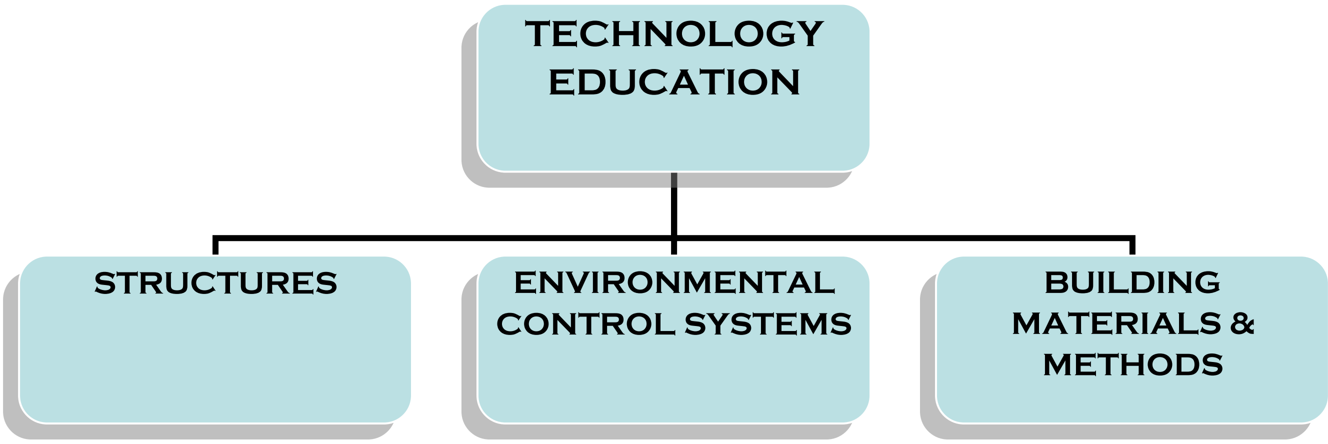

Figure 2.2 : The Triad of Architectural Technology Education
Source: Allen (1997)

Black (1993) opined that the supreme goal in the design studio is making beautiful structures, and assessment with great emphasis on successful integration of the engineering structure with the architectural space. This integration appears to be the answer to the problem of design-technology schism in architectural education. Vamosi (1993) described this integration as *architechnology,* that is uniting technology and architectural theory (as reflected in design). In recognition that integration is the panacea in bridging the design-technology gap, varied strategies have been developed by instructors in an attempt to bridge this gap.

(i) Structures

While the architect is not expected to take up the role of the engineers and allied professionals, he is expected to know enough about each of the different processes and inputs that go into a building to enable him correlate varied information from the different professionals for informed decisions. Structures as a critical component of technology education in architectural education is one area the architect is expected to be competent. To situate structures within the confines of architectural education and architectural technology, an articulation of the morphology of the word might be necessary. This may be seen in a precise articulation of what can be referred to as natural structures as compared to architectural structures.

(ii) Natural Structures: The Structures in our lives (Nature)

Onouye and Kane (2002) defined a structure as something made up of interdependent parts in a definite pattern of organisation – that is an interrelation of parts as determined by the general character of the whole. The definition of a structure in this sense is general and very broad, which is applicable to various systems, for example the structure of a family, an organisation, a country (leadership structure), the structure of an academic programme and others. However, Gordon (2003) provided a scientific dimension (as can be seen from nature) to the definition of a structure, in noting that a structure is any assemblage of materials that is intended to sustain loads and the study of structure is one of the traditional branches of science. Whereas both perspectives provide different views (non-scientific and scientific) on what a structure is, they both tapered towards a convergence, which can be described as the universality of structures, i.e. structures in everything. Onouye and Kane (2002) posited that the subject of structures is all encompassing; everything has its own form. A cloud, a seashell, a tree, a grain of sand, the human body-each is a miracle of structural design. Gordon (2003) also asserted that structures are involved in our lives in so many ways that we cannot really afford to ignore them. This is because according to Gordon (2003), every plant and animal and nearly all of the works of man have to sustain greater or less mechanical forces without breaking, and so practically everything is a structure of one kind or another.

(iii) Architectural Structures: The Structures in Buildings

Architectural structures as distinct from natural structures or structures in nature can be seen as the structures in buildings, which is essentially the support systems in buildings. Onouye and Kane (2002) noted that the primary function of a building structure is to support and redirect loads and forces safely to the ground. Building structures are constantly withstanding the forces of wind, the effects of gravity, vibrations, and sometimes even earthquakes. Place (2007) described architectural structures as the systems and methods put in place to make a building withstand all the forces to which it will likely be subjected during its lifetime.

Essentially, architectural structures is the support system (skeleton) of buildings with respect to its external environment (imposed loads- wind load, snow load, live loads and self-weight) and internal environment (the reactions taking place within the building as a result of the imposed loads).

(iv) Pedagogy of Architectural Structures

The universality of structures and the function of structures in architecture succinctly indicate its significance and relevance to architectural design. Underscoring its importance, Salvadori and Heller (1963) noted that structure is an essential component of architecture and in a sense has dictated architecture. Despite its widely accepted relevance to architecture, the pedagogy of architectural structures has been a major concern to architectural educators and theorists. However, this concern climaxed in 1976 as noted by Black and Duff (1994), when the Association of Collegiate Schools of Architecture (ACSA) mandated an *ad hoc* committee on the growing dissatisfaction with the effectiveness of the teaching of structures in schools of architecture. Further to these concerns, instructors began to develop innovative approaches and strategies for structures instructions (Vassigh, 2001 and Dytoc, 2007). To accurately discuss the instructional approaches in architectural structures, it is noteworthy to discuss the objectives of the pedagogy of architectural structures. This becomes imperative so as to provide benchmarking parameters for the instructional approaches.

2.2 Pedagogical Objectives of Architectural Structures: *Structural Literacy versus Structural Competence*

The aim of any form of learning in architecture is, majorly, to train the student for active participation in community and national development and generally in the architecture profession (Larrick, 1949). This global objective of architectural education is connotative of the ability to use and apply acquired knowledge to solve real life problems especially as it relates to design problems. Noting the integral role of structures as a potent sculptor of form-form giver (Dytoc, 2007) and support system in architectural design, acquisition of a thorough knowledge of the subject matter is imperative. This process of knowledge acquisition is what is generally referred to as literacy. In outlining pedagogical objectives in structures, Ochshorn (1990), observed that an attempt should be made to define what exactly constitutes *structural literacy* for students; and to make a careful distinction between literacy and the idea (ideal?) of *structural competence*.

Trilling (1984:70), argued that "*we are literate in a discipline when we understand its presuppositions, its research techniques and some of its more important results. We are competent in it when we are able to use it for our own purposes."* At this juncture, it becomes critical to identify what is and what should be the goal of teaching architectural structures. From the foregoing discussions, and viewed from the lens of Larrick's (1949) definition of the primary aim of all courses in architecture as the application of knowledge to solve real life (design) problems, it may well be appropriate to state that *structural competence* should be the goal of pedagogy of structures. This implies that two instructional outcomes/concepts now exist. These are structural literacy which is possession of structural knowledge appearing first (apriori) in the instructional sequence, and then structural competence i.e. ability to use structural knowledge to solve design problems). The discussion so far may therefore lead to the question of, "how and when does structural literacy translates to structural competency"?

Salvadori (1958) in noting the pre-requisite role of mathematics in structures observed that there was a gap that must be filled between the theory of mathematics and the art of using it. Salvadori (1958:7) made it clear that *"people like Nervi, Candela, or Torroja knew structures well enough beyond codes and calculations. They transcended mathematics into the sphere of* *intuition in structural design. They forgot mathematics and followed their intuitive feelings about how a structure will work".* It was based on this premise that Salvadori, adopted an intuitional approach based on models in teaching structures to architects. An intuitive understanding of structural engineering grounded in real world examples is vital to inculcate structural innovation in architecture student's future work (MacNamara, 2011). This intuitive understanding of real world structural concepts is what has been described as *structural intuition* by Allen (1992). From the foregoing, it can be inferred that the development of structural intuition is what leads to structural competence and not structural literacy. Though it must also be noted that structural intuition is not possible without structural literacy, however, structures instruction may stop just at structural literacy and not proceed to structural intuition, which yields structural competence.

At this juncture it is important to note that *structural literacy* and *structural competence* are two possible outcomes of structures instructions with the latter as the preferred, desired and anticipated objective. The figure 2.3 is a chain-link of outcomes of structures instructions as conceived by the researcher.

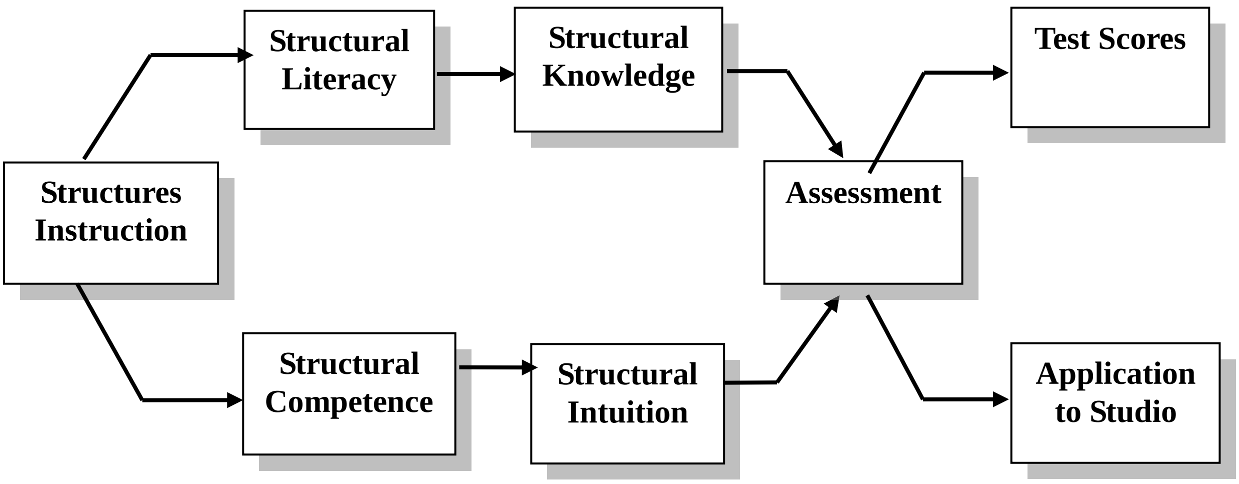

Figure 2.3: Learning outcomes of Structures Instructions.
Source: The Researcher's conception (2013).

Further to this benchmarking, a discussion of instructional approaches to the pedagogy of structures becomes contextualized. The following section is therefore an attempt to situate and provide an overview of instructional approaches to architectural structures.

2.3 Instructional Approaches in Architectural Structures

Several scholars have attempted to identify and tag instructional approaches in structures. Black and Duff (1994) for instance identified two approaches: conventional teaching approaches and unconventional teaching approaches. Vassigh (2001) also identified two approaches, which are engineering approaches and alternative approaches. Dytoc (2007) noted that there is a traditional approach to teaching structures and alternative teaching method. A recurring theme among these authors' submissions is that there are two broad categories irrespective of nomenclature which these approaches can be classified. These are :

i. ***Traditional approach and***
ii. ***Alternative approaches.***

The following paragraphs present discussion on these two approaches

2.3.1 Traditional Approach

Vassigh (2001:92) observed that "*the traditional engineering based approach is essentially a derivative of the historic development of scientific thinking, the evolution of the engineering discipline and the changing role of architecture*". The growing influence of the engineer within the building industry has resulted into an infiltration of sophisticated mathematical models into the construction process. Thus, scientific thinking and mathematical rationalism have become the prevalent approaches to teaching structures. Black and Duff (1994) observed that due to these antecedents, current structures courses are usually offshoots of conventional teaching models that emanated from engineering schools. They further noted that engineering based instruction is mostly quantitative, communicating basic concepts using an advanced mathematics nomenclature. This approach, Dytoc (2007) observed is a symbol-laden vocabulary of mathematical formulae. It is a quantitative approach which is highly numerical. It is worth noting as argued by Vassigh (2001) that architecture students neither have the background, disposition, nor time to master the mathematics skills required to understand or utilize a system based on highly mathematical models. This is the engineer's perspective to structure which may be averse to the architects learning disposition.

Black and Duff (1994) also observed that the conventional approach followed by engineering schools where students master the materials incrementally and only after four or five years begin to study the subtleties of structural behavior, is in fact impossible for typical architecture students. Bender (1976:1) had earlier argued that "*the classical sequence of presenting physics, statics, and strength of materials, analysis and "design" may present a logical progression of information, it is however, disconnected from the total design process"*. This sequence he noted has produced architectural graduates with little or no understanding of the basic principles of structures, can neither apply them, nor retain them for a significant period after graduation.

2.3.2 Alternative approaches

In the face of the dilemma that architecture students quickly become uninterested, frustrated, or even intimidated by the structures curriculum (Vassigh, 2001), new methods, alternative teaching resources and textbooks that seem responsive to the competencies, needs and perspective of the architecture student have been developed though not widely adopted. Instructors have adopted several alternative approaches to the problem posed by the conventional approaches to teaching structures. Findings from the literature search indicate a number of alternative approaches that may be broadly summarized as follows:

i. *Analogue Visualisation-Based Learning (AVBL)*
ii. *Digital Visualisation-Based Learning (DVBL)*
iii. *Web-Based Instruction (WBI)*
iv. *Case-Based Learning (CBL)*
v. *Problem-Based Learning (PBL)*

(i) Analogue Visualisation Instruction (AVI)

The Analogue Visualisation Instruction (AVI) is characterised by hand-drawn/manually-generated graphics, usually in the form of sketches, drawings, pictures and physical models and multiple solutions. Salvadori (1958:7) argued that "*building demonstration models for structural behavior, commencing with basic ideas, simple tension, simple compression, proceeding to bending, buckling, to arch action, from one dimensional to three dimensional structures could lead to coverage of a large amount of material in a short time"* (pg. 7). He recognized the extent and limitation of this approach, noting that though the students may be incapable of precise structural design (incapable of structural analysis, unable to determine safety factors, ignorant of code requirements), but are structurally competent to concieve acceptable and serviceable structures. The envisaged result of this approach is to groom a new breed of architects who understand structural behaviour, even in apparently complex structural situations.

Pleusms (1974) also argued that students spend two to three years laboriously learning skills that they will hardly use once in practice. The students are expected to integrate this knowledge in their design, yet the design proposals of architecture students often seem to lack the most elementary knowledge of structures. Furthermore, he opined that mathematical methods assure safety and economy and indirectly help to develop a sense of scale of the structure, noting however that judgment hardly stems from the use of mathematical formulas. He reported that the University of Oregon's alternative approach which is a non-mathematical structures course that seeks to examine the behaviour of specific structural systems and their architectural implications. It is essentially a comparative study of structures, geared towards equipping the students with an overview of all structural systems. It emphasizes identification of the fundamentals of each structural system, appropriate use of and creative structural design. The basic approaches employed at attaining understanding of structures are model construction and graphic comparisons.

Dytoc (2007:52) also noted the poor outcome of the traditional approach of teaching structures to architects and argued *that "architects communicate with graphics and models, not the symbol-laden vocabulary of mathematical formulae"* and thus evolved an approach that uses graphics effectively. Salvadori (1958) had posited that "*architects and engineers do not have a common language"*. Relying on this notion of language barrier (difference in language), Dytoc (2007) adopted an approach that sought to teach structures using the architects vocabulary. He observed that graphics significantly help in clarifying structural topics. His approach combines familiar everyday language and examples that most people can recall or imagine. Efforts at understanding the working principles of structural behaviour precede introduction of computations as tools of precision. Image retention is enhanced through lecture-shows that come with music, by taking advantage of the emotional element present in music. The lectures adopted an education cum entertainment ("edutainment") approach by engaging several media concurrently: information about the case study, colour images of the projects and its details and background music tie it all together. He reported that respondents to course evaluations over a period of two years revealed strong support for these graphic methods expressing that the alternative methods made learning structures more engaging and interesting.

(ii) Digital Visualisation Instruction (DVI)

Digital Visualisation Instruction (DVI) is characterised by the use of computer-generated graphics and visuals. These include computer-aided drawings, sketches, pictures, use of structural analysis software (Finite Element Analysis, DEFLECT, ARCADE, CASDET), animation/interactive models, web-based, multimedia, computer generated models and multiple solutions.

Information Communication Technologies (ICTs) have been described as having the potential to transform education, with its advocates claiming that it has the power to radically change classroom practice (Wang, 2009, Vassigh, 2001, Black and Duff (1994). Building upon latest developments and innovation in ICTs, Vassigh (2001) developed a series of animation instructional tools. Vassigh (2001:93) reported that "*using computer-generated models, interactive images, and animation, integrates quantitative engineering methods with qualitative approaches using a wide range of digital visualization devices".* That study argued that by using audio to clarify fundamentals, students can concentrate on the animation and directly associate complex structural concepts with visual demonstration of structural behaviour, rather than extracting these ideas from written text and mathematical symbols. "*A key advantage of deploying digital animation technology is that it enables fabrication of visual environments purpose made to demonstrate complex concepts in an easy to understand visual means"* (Vassigh,2001:93). Digital manipulability or simulation of these environments to emphasize or de-emphasize certain structural members further accentuates its teaching capability.

Black and Duff (1994) reported a six-year study employing an alternative instructional approach and advanced structural engineering software to teach structures to architecture students at the University of California. The model as reported by Black and Duff (1994) uses the Finite Element Analysis (FEA) and a revised curriculum that seeks to juxtapose the contents of the structures curriculum, which is a departure from the classical sequence of presenting the material incrementally.

Their model is hinged on the assertion that much of the detailed material in broad engineering curriculum is not necessary for architecture students, and thus it can be bypassed. This assertion has been confirmed by several scholars (Allen, 1992; Martini, 2006; Muttoni, 2006). Findings from the literature review indicate the development of some computer aided learning packages. Some of these are outlined and reviewed in the following paragraphs:

a. DEFLECT

DEFLECT is the outcome of a Scottish Higher Education Funding Council (SHEFC) sponsored project collaboratively undertaken by the Department of Civil Engineering, University of Paisley, the Mackintosh School of Architecture, and Lamp Software. It is a computer-assisted learning (CAL) software designed to simulate the response of structures to different loading conditions. DEFLECT consists of three levels: Level 1(Beginners), Level 2 (Intermediate) and Level 3(Advanced). Level 1 is aimed at enabling understanding structural behaviour of building components. Level 2 aids students to draw with precision the structural system of their architectural designs, examine the deflection of structural members and identify critical sections-areas of tension and compression. Level 3 enables students design and analyse realistic structures by selecting appropriate structural members, and specify materials and multiple loads (MacCallum and Hanna, 1996)

An appraisal of the pilot testing stage of its development by students from the two aforementioned institutions showed that students expressed a high level of 'satisfaction' with many of its pedagogical features and tools. Some of the deliverables of the software includes promoting and enhancing students' understanding of the response of structures to loads, helping students comprehend the impact of varying mechanical and cross-sectional properties of materials on structural behavior (examining the impact of factors such as elasticity, ductility, brittleness, moment of inertia, centroid etc on the form and performance of structural members).

b. **CASDET**

CASDET, developed by Picolloto and Rio (1995) is abbreviation for Computer Aided Structural Design Education Tool, which is interactive software for structural simulation and design for educating architects and civil engineers. It comprises five modules (tools) and an interactive interface. The graphic tool enables the students in drawing structural members, importing and editing pictures. The Structures tool is used for designing and analyzing complex and large structures and the exploration of properties of structural members while the mathematical tool is used for mathematical operations. Instructors are able to design standardized assessments using the CAI-tool. The video-tool is used for animation and visualisation, and presenting laboratory experiments on structural members and show photorealistic images of existing buildings and structures. The development of three dimensional (3-D) objects and the examination of the behaviour of skeletal structures are undertaken using the 3-D tool.

c. CADS

The Computer Aided Design Software (CADS) is more advanced software designed to be highly professional both in its unique outlook and user-friendly interface. It is a platform for analysis of both two dimensional and three dimensional structures. It has a limited usage in architectural education and practice due to its complexity and incompatibility with the design process.

d. ARCADE

ARCADE is a structural analysis programme (for simulation and analysis) developed by Kirk Martini of University of Virginia. Its uniqueness lies in its interactive interface and the analytical methods, which were both derived from computer games. The gaming software architecture of ARCADE allows the analysis and the interpretation stages to be merged, thus making interaction with a model possible while an analysis is in progress. Another unique feature of ARCADE is that effects of changes made to a model can be seen instantly in the manner a game player sees a game respond to inputs (Martini, 2006). It employs a computation method, known as physics engine or particle system commonly used in computer games to model the physics of moving objects with greater visual realism. Yale University and University of Virgina have deployed this model in teaching architecture courses.

The developer noted that "*while it is widely accepted that students should learn statics before they begin working with structural analysis software, because it is believed that without knowledge of statics, students will not be able to understand what the programme is doing, experience with ARCADE has shown that it can be used to teach statics from the first day, because it is based on the fundamental physics of F=ma*" (Martini, 2006:279). Despite the identified merits of ARCADE, it is not without some limitations. Martini (2006) identified three limitations associated with ARCADE. First, the software is limited to two-dimensional (2-D) analysis; meaning that it cannot perform three- dimensional (3-D) analysis. This limitation deprives the student of the potential of three- dimensional (3-D) images and analysis in providing greater comprehension of structural knowledge. Second, is that it is limited to small scale problems, as the analysis runs in real time, and thus it is computationally demanding. While this is a significant limitation for commercial application, it is not for teaching. Third, and last limitation is the non-availability of section library or code check as is the case for commercial applications. However, the developer has argued that Code checking would not be appropriate for ARCADE, since the focus of the programme is realistic behaviour.

Martini (2006) notes that ARCADE essentially set out to challenge two established traditions in teaching structures. The first, is that the use of structural analysis software by students should be preceded by efforts to make them learn statics manually. Use of ARCADE has revealed that structural analysis software can be an effective tool in teaching the most fundamental concepts of statics. The second, suggests that learning structural analysis software should progress gradually from linear elastic static analysis to more complex mathematical methods. Experience with the use of ARCADE has also proven that its non-linear dynamic analysis method can be an appropriate entry point for learning structural behaviour and analysis. Although documented evidences of ARCADE abound, it is important to note that there has not been any documented empirical data known to the researcher to support its claims.

(iii) Web-based Instruction (WBI)

Web-based Instruction (WBI) is synonymous to Digital Visualisation Instruction (DVI) in the sense that they both rely on the concept of computer enhanced visualization. A key advantage of WBI over the DVI approach is the potential to give the instructional tool the widest possible reach. WBI only differs in its use of online resources. An exemplar in this categorization is the Structure and Form Analysis Software (SAFAS) educational tool. SAFAS was aimed at helping students gain better understanding of the integration of structure and form. The developers noted that the software was an attempt "*to assist students become better and more innovative practicing architects by applying principles of Human-Computer Interaction (HCI) and best pedagogical practices to build online resources and tools that bridge the design gap between structure and form in architectural education"* (Setareh, *et al.*, 2011:2).

It comprises two modules: the knowledge base website and the Structure and Form Experimentation system (Setareh, *et al,* 2011). The knowledge base Module provides textual, graphic, and animation information on various aspects of spatial structures. The Structure and Form Experimentation Module enable students fabricate digital models of various structural elements and systems and visualise their structural behaviour (i.e. their reactions in terms of member forces and joint deflections) under different loading conditions. It consists of two modes: the Pre-Analysis Mode (in which the user defines the structure and the applied loads), and the Post-Analysis Mode (in which the user investigates the effects of the loads on the structure).

In a study to assess the efficacy of SAFAS, an evaluation of its use with thirty (35) architecture students in an undergraduate building structures course at a large, public university in eastern United States was done (Setareh, *et al.*, 2011). The results of that study indicated among other things*;* that students learnt new knowledge and skills, the material was found to be interesting and provided visualization of structural behavior that has been analysed after manipulation. The package also enabled students acquire a better understanding about spatial structures and the relationships between structure and form.

(iv) Case-based Learning- Precedent Study

Case-based instruction (CBI) is a system for delivering instruction by the use of cases or precedents. This is otherwise known as case-study. The development of the "case method" approach has been attributed to Christopher Columbus Langdell (1870). (Barry and Yardav, 2007:1), cited Christopher Columbus Langdell's position that "*the most effective way to study law was by examining actual legal situations (cases) and that "understanding, in turn was best developed via induction from a review of those appellate court decisions in which the principles first took tangible form"*. He posited that such "*use of cases would prepare students for the real world of practice"*. The use of case studies as an instructional approach is not strange to architectural education. It is usually a mandatory tool in acquiring design information during the design process as taught in the design studio. Noting the potential of case studies in the design studio in facilitating understanding of concepts from existing cases and consequently applying them to solve existing problems structures instructors have made attempts to creatively deploy this approach to enhance comprehension of structural principles. The findings of a study by MacNamara (2011) on the use of case-based learning in teaching structural analysis to architecture students indicate that it is a useful learning tool. That study observed that an intuitive understanding of structural engineering grounded in real world examples is vital to inculcate structural innovation in architecture student's future work. While case-based learning also known as precedent study can make use of either historical or contemporary cases, the approach used by MacNamara (2011) was that of historical cases. The approach used historical precedents in two ways: as lecture examples introducing the fundamentals of architectural structures; and as specific case studies undertaken by the students as course work. Structures exemplifying the very best of structural engineering that embodies the principles of efficiency, economy and elegance serve as excellent teaching models in engendering an appreciation for the role of structures in architectural design (Billington, 1985; and MacNamara, 2011). MacNamara (2011) noted for instance that, an examination of the Iron bridges of Thomas Telford is a classic example of the mathematics of the cable and the arch. The Eiffel Tower is also cited as a relevant example on the subject of bending moment diagram (dreaded by a lot of students). The structurally expressive ribbed domes, slabs, and barrel vaults of Pier Luigi Nervi also provide meaning insight in understanding the naturally difficult shells and plates. The works of Candela and Torroja provide an insight into how a properly designed shell can provide structure, enclosure and aperture. That study also identified "*the use of Hancock Tower and the Sears Tower (Fazlur Kahn-architect and Bruce Graham-engineer) to serve as both an introduction to the most widely used forms for tall buildings and how the architect-engineer relationship can result in a synergy that creates something entirely new that neither discipline would likely produce in isolation"* (MacNamara, 2011:4). As part of the requirements of the course, students were expected to undertake an original structural analysis of their chosen structure enumerating the primary structural mechanism that supports it. An integrated discussion of the functionality, historical, political, economic and architectural context of the structure was expected to accompany the students' submission.

Findings from that study indicated overwhelmingly positive response from the students onn the study of historical precedent in structures noting that it added value both in learning the new concepts and in appreciating the usefulness and relevance of those concepts to their own work. The study further identified that historical precedent was able to stimulate students' engagement in both structures and the application to their design studio. Responses from the students showed that the practicability of the historical case studies made them useful pedagogical tools. The study concluded that "*historical precedents of structural innovation are an extremely useful tool for both teaching fundamental structural principles and in activating the relationship between history, structure, and design"* (MacNamara, 2011:14).

(v) Problem-Based Instruction-Learning

Problem-Based Learning (PBL) is an interesting instructional strategy. Unlike the conventional teacher centered learning where students are assumed to be empty and the instructor fills them with knowledge and concepts of a particular field, rather students are guided to acquire knowledge by solving real (though simulated) problems that reflect the decisions and dilemmas people experience in everyday life. It originated in the 1970s in the medical sciences where it is the dominant teaching mode for the first two years of medical science curricula. It is widely argued that PBL is a powerful and engaging learning strategy that leads to sustained and transferable learning (Mergendoller, Maxwell, Bellisimo, 2006).

"PBL is different from the conventional instructional strategies by restructuring traditional teacher-student interactions toward active, self-directed learning by the student. Teachers guide students by providing suggestions for inquiry or further study but do not assign predetermined learning activities. Rather students pursue their own problem solutions by clarifying a problem, posing necessary questions, researching these questions, and producing a product that displays their thinking. These activities are conducted in collaborative learning groups that often solve the same problem in different ways and arriving at different

answers" (Mergendoller, Maxwell, Bellisimo, 2006:50). It promotes a student-centred learning approach contrary to a teacher-centric approach. Problem based learning is used interchangeably with project based instruction. It has been adopted in architectural structures in different forms, but without a specific and unique identity. The three main forms of PBL in architectural structures are:

i. *Learning by Doing Approach (LDA)*
ii. *Group Construction Project (GCP)*
iii. *Design-oriented Approach (DOA)*

i. Learning by Doing Approach

Yazici and Yazici (2013) reported an empirical study on the building mechanics course (a synthesis of statics and strength of materials) for fifty-seven (57) freshmen students of architecture at the Istanbul Kultur University, Turkey. That study was aimed at increasing students' motivation towards the course and to facilitate their understanding of the theoretical concepts of mechanics. The statics component of the course was focused on developing a solid understanding of the behaviour of rigid bodies under forces and moments as well as the mechanical abstraction of the structural loads. The strength of materials component of the course is focused on the behaviour of deformable bodies. The concept of stress and strain, the mechanical properties of materials as well as the fundamentals of the design of beams, columns and the structural connections are covered within the scope of strength of materials.

The participating students were given the task of holding an object with a mass of at least 150 grams in the air without a direct support from underneath. Materials commonly suitably for architectural models such as balsa wood, string and cardboard were used. The largest dimension of the models was limited to 50 centimeters. Students were asked to consider the aesthetic aspects just as well as the structural aspects of their design. Instructions were kept as vague as possible in order to avoid the effects of design fixation (Yazici, 2011). The timeframe for submission of models was two weeks, which was to be accompanied with a brief written report describing the difficulties they encountered in assembling the parts and making the model to stand up.

Feedback from brief interviews with a limited number of students conducted on the working principles of their models at the end of the study indicated that creating simple physical models and orally communicating their design process had a positive impact on the motivation of the students towards the course. It was also observed that the study identified a major challenge in integrating theoretical knowledge gained from structural engineering with practice or their design due to students' difficulties in switching back and forth between different modes of instruction. That study also revealed that the design studio, which is the core of the architectural design education, was based on the principle of "learning by doing" whereas structural engineering courses such as structural mechanics was based on the use of mathematical abstraction to communicate concepts of physics in a classroom environment.

ii. Group Construction Project (GCP)

Another variant of the learning by doing approach is the Group Construction Project (GCP). The GCP was developed at the Auburn University, Australia. This is also based also on the premise of the ineffectiveness of the traditional engineering approach to structures as students struggle with structural concepts and fail to see its practical significance. An informal survey of students and alumni members perception of the course was done over a period of two years, (that is without the use of sophisticated analytical or statistical tools). The two most prevalent criticisms identified with the course were:

i. *"Considerable information presented in class had little applicability to the daily problems faced in construction; and"*

ii. *"A lack of enthusiasm was evident when lecture format was the only method used to transfer information."* (Hein and Williams, 1990:2),

Further, with the former bothering on course content and the latter on teaching methodology, two actions were taken to relieve students' frustration. The first was changing the course content to reflect the construction context and the second was to supplement the lecture format with activities that stimulate and motivate the students. The GCP was, one of the lecture supplementary activities, which was reported to have proved the most effective among several other initiatives.

Hein and Williams (1990) noted that the GCP was designed originally to offer a practical construction dimension unavailable to majority of students. Students were to undertake construction of a small building, including client contact, structural design, cost estimate, and execution of all building phases. Upon completion, group members (made up of 4-7 students) make a presentation of their experiences to the class. The project which must be approved by the instructor was either student suggested or assigned by the instructor.

Hein and Williams (1990) reported on one of the completed projects. The project involved an addition of a roof projection to an existing building. The area was four (4) metres wide and eight (8) metres long and no walls were required, but a 100 millimetres slab was needed. During the pre-construction stage, the group carried out a detailed structural analysis of the joists, the girder, and the supporting columns. The analysis was a mandatory portion of the project and was submitted with other documentation at completion. The construction began after extensive planning with every team member playing different roles.

The developer of GCP noted that building an actual structure provides the student with a practical context for learning structural principles. The project was also able to improve students' motivation level and degree of enthusiasm. The developer further noted that the act of building allows students to experience many hidden principles of structures including lateral stability. Beyond technical skills, students were required to imbibe and demonstrate leadership, cooperation, clear communication skills, and hard work required in completing the project. Feedback from course evaluations by the students indicated that the group project helped students' to acquire new knowledge, develop better understanding, and enthusiasm on the subject of structures.

iii. Design-Oriented Approach (DOA)

One way to make structural systems part of the "intuitive" design vocabulary of architecture students is to remove structures from the abstract realm of mathematics and bring it into the context of building design (Chiuini, 2006). Design –Oriented approaches are attempts to reach structural understanding via the design studio. The core of this approach is to teach structural concepts by solving a design problem, and thus achieving deep learning by a two-way process of acquiring and applying knowledge simultaneously.

A number of approaches have been developed in this regard. These are:

a. The Total studio (Levy, 1980)
b. The Second studio (Allen, 1997)
c. The Structures Project (Chiuini, 2006)
d. The 2 plus 1 studio (Schoenefeldt, 2013)

The next paragraph examines the key precepts of each of these approaches.

a. The Total Studio

The Total Studio is an ideal pedagogical construct, representing the holistic approach to architectural education (Levy, 1980). While a good proportion of architectural educators and programs aspire to achieve this, only a few have partially achieved it. This academic model often plays an important role in discussions of how to teach technical subjects. The Total Studio is a collective idea and a continuum of shared understanding rather than a specific programme. It is conceived as a scenario for relating technical courses to the architectural program and presents the design studio as the best opportunity for teaching architecture. The studio is the only environment in which all aspects of architectural ideas and skills - formal aesthetics, building technology, theory, history and drawings - can be learned. This suggests that all learning should be structured around, and reinforced through, comprehensive design problems where creative opportunities are revealed and design implications tested.

Levy (1980) observed that in the total studio, data required to solve the technical problems are provided either by direct research or in tightly organized support lectures given by studio faculty. The students are perceived as intensely motivated to learning all aspects of architecture and the studio faculty are portrayed as academically and professionally experienced generalists who probably, but not necessarily, have different areas of interest. The studio, in this scenario, assumes full responsibility for effecting the integration of design with every other area of content. In contrast, the traditional model of architectural education takes a far less holistic approach. The separation of the curriculum into studio and non-studio components is fully accepted as the only “workable” option. Non- studio courses are assigned a clear support position: to provide the data, the technical concepts, and the theories, which students can use in their design projects. Also non- studio courses are expected to coordinate, adjust and respond to studio requirements. In fact, studio is viewed as the given while construction, structures, theory, and everything else are variables.

Implementing the Total Studio has been besieged by a number of difficulties and resistances. A fundamental criticism is the lack of time. Faculty complain that "there are so many competing issues to be woven into studio in so short a time that building technology simply takes a back seat to formal issues." There is a price to be paid for surrendering the completely independent syllabus. Integrated schedules mean shared priorities, which in turn cut into time and affect sequence. However, if one accepts the contention that more learning of lasting value will occur through the integration of course and studio, despite the reduced lecture time, then the effort will be judged worthwhile. Another criticism is the strange argument that technical considerations constrain the creativity of developing architects.

b. The Second Studio- Allen (1997)

"*Knowledge presented ahead of any attempt to apply it cannot find a conceptual schema in the student's mind in which to reside, because the required schema can only be developed while struggling with a particular problem….The two sides of knowledge acquisition and application must be attacked simultaneously"* (Gelernter, 1988:49). Experience has revealed that students learn technical skills more efficiently and incorporate them more readily into the building design process when the skills are learned on an as-needed basis during on-going design projects (Allen, 1997).

Based on this premise, the Second Studio, Allen (1997) noted was developed as a model for technical/technology teaching in which technical "support" courses (such as structures, building methods and materials, and environmental control systems) are replaced by "technically oriented design studios" that students take along with an unrelated conventional studio. He further noted that the design project in a technically oriented studio is carefully articulated to feature specific technical issues while minimizing distractions. Special lectures integrating technical, formal and spatial issues are provided within the studio, on an as needed basis with the goal of creating good buildings.

Allen (1997:92) noted that the "*information carryover from classroom teaching into studio utilization is perhaps 20 percent from the best –taught technical course, while the information carryover from as-needed studio lectures into studio utilization is at least 70 percent"*. This suggests that the latter model is educationally superior. In the second studio, the emphasis is on the selection and configuration of technical systems as integral components of the emerging architectural design. Selection and configuration are the most important phases of technical design activity, yet they are precisely the phases that are taught least in most schools today. For example, the exact sizing of beams, columns, ducts, and the other technical components of buildings are the least important aspects of technical design activity that need be taught only to the extent justified by the given design problem. Making a Second Studio work would require great care in planning and logistics. Ideally, each term should be scheduled cooperatively by all of the studio teachers so that second and primary studios do not require major submissions in the same week. This is to ensure that there are several "pressure-free" weeks in the term when neither studio requires a major submission.

The implication of this is that a second Studio must be planned with exceptional care. It is not just a matter of handing out a design problem and then lecturing on whatever technical problems arise. The site and the design problem must be very carefully selected and formulated to bring out particular technical problems and opportunities and to minimize distracting issues. The second studio creates a problem-based learning environment, which has been the core essence of enhanced learning potential of the design studio in architectural education. In this context, the students seem to absorb more technical information and use it better than those who merely take a classroom course in the subject. Cooperation between teachers of primary studio and second studio to avoid clashes in submission dates and so that there are several pressure-free weeks in the semester is very crucial in achieving the goals of second studio.

c. The Structures Project- Chiuni (2006)

The Design-Oriented Approach developed by Chiuini Michele at the Department of Architecture, Ball State University, is aimed at bringing structural creativity into the design studio via two approaches: by making structural design an integral part of the studio problem statement; and by introducing a degree of “realism” into the structures courses by a teaching around a building design project.

The first approach is described as the Structures Project with an emphasis on" integrated design". In the structures project, students are asked first to configure a system in the context of a basic architectural brief. Thereafter each primary element of the system is analyzed, members are sized and connections designed. The structural systems designed include mainly steel and wood long span, and steel and concrete multistory. Chiuni (2006) noted that this approach seeks to address one of the surprising student attitudes: the idea that in a structures course they are not designers any longer, but only formula solvers. There is a frame of mind in the student sitting in front of his/her structures assignment (which would deserve some psychological attention), that makes students forget how to draw and design, or think that, because it's not studio work, their drawings can be sloppy. Thus, constant effort is made to make the students sketch (see figure) as they think about the structural problem, versus jumping into the formulas. Students are expected to submit structural drawings with the same graphic quality (and probably more precision) that they would adopt for a studio project.

There are two variables that the students are asked to consider as they approach the problem: the configuration and the construction. These two variables have to do with loads and with the understanding of how loads are transferred to other structural members as they travel down to the foundations. Exploring these two variables helps the students to relate better to building technology and architectural design. One could say that an understanding of structural design is not complete when divorced from knowledge concerning materials and methods of construction. The design process for the projects is paralleled to the introduction of related topics in the lecture course.

The second approach is implemented by the use of structural analysis software, with emphasis on "systems". Chiuni (2006) asserted that there seems to be some degree of consensus that the main objective of structures courses should be the understanding of structural behavior. This assertion was premised on the findings of a 1995 survey which indicated that the two primary objectives of structures courses were the qualitative and intuitive understanding of the behaviour of building systems, and the quantitative (mathematically based) analysis skills. Based on the foregoing, computer analysis is used in the course to teach different relevant structural systems, ranging from concrete frame (used to introduce statically indeterminate systems) to steel, arches and domes. The software used has the ability to calculate and visualize the deflections offering an additional tool to study the optimal configuration and combination of member sizes. Using a design project to discuss any of the related topics helps the students to be grounded in structures (Chiuni, 2006). Just as in the first approach, students then design the main structural members such as beams, columns, footings and steel reinforcement.

It is argued that the Design-Oriented Approach (DOA) provides a holistic view of the system which would have been impossible with the traditional approach. DOA does not preclude possible criticisms of using computer software to solve problems of statics, a fundamental one, which is the "black box syndrome". The computer analysis produces results students have to use blindly, without understanding how they are worked out. This is taken care of by a series of introductory lectures on statics and other relevant areas with the aim of providing basic understanding of internal forces and deflections in structural members.

The developer noted that because the course is not really about statics but design of structural systems, students can focus on the understanding of principles and processes of structural design. This perspective can help students to see the mathematical calculations not as an end to themselves but as a design tool. DOA has also attempted to leverage on the possibilities of the computer in enriching structural creativity by enhancing understanding of structural behavior. The structural analysis software is able to allow for greater focus on structural behaviour by saving precious time and mental energy involved in complex calculations. Computer modeling of structural members help to provide deep understanding of structural concepts through the concretization of abstracted concepts made possible by visualization. Conclusively, the developer argues that a structural design course using design projects can provide the necessary degree of rigor and depth required for effective integration of technology in the design process.

d. The 2 Plus 1 Studio model

Developed in 2013 by Henrik Schoenefeldt at the Kent School of Architecture, the 2 plus 1 studio model was aimed at achieving a better integration of technology and environmental (T & E) teaching within the architectural studio. An appraisal of this model showed that students valued the new approach to studio teaching, stressing that it enabled them to investigate the technical and environmental issues over the course of whole term but also in the immediate context of their evolving design proposals. The first objective is to teach environmental design (ED) as an activity rather than a purely theoretical subject. Similar to architectural design, students are experience environmental design as an iterative learning process, in which design propositions are presented, critically reviewed and gradually refined over the period of a whole term. In the traditional teaching model, environmental design is taught separately from the studio and largely as a theoretical subject. The traditional approach does not address the question of how scientific methods used in structural and environmental design can be used as means to critically evaluating and refining technical design solutions.

The second objective is to achieve a closer integration of technical and environmental investigations into the overarching architectural design process. The 2 plus 1 model is an attempt to fill the gaps observed from the Total Studio and Second Studio. Findings from Schoenefeldt (2013) revealed that the Total Studio, which refers to a teaching model in which all technical teaching is delivered within the architectural studio, poses some major pedagogical challenges in practice. Although it was very strong in promoting integrating design thinking within the studio, it did not achieve the same level of technical rigour as the traditional model. It did not provide sufficient dedicated space for a more focused and in-depth technical investigations before engaging in the process of full integration. In an attempt to overcome this problem, Allen (1997) introduced an alternative model, the Second Studio. The Second Studio is a technically focused studio, running parallel with the traditional design studio. It was very successful in getting students to participate in technical and environmental design investigations over the course of a whole term, but it did not sufficiently address the challenges of integrating technical studies into their architectural design projects, it rather reinforced the divide. The challenge was therefore how to achieve a balance between a more focused environmental and structural design investigations and the integrating of architectural, structural and environmental aspects into one unified design. This balance was addressed by the adoption of a new studio-teaching model, known as the 2 plus 1 studio.

The 2 plus 1 studio combines a two-studio system with a series of intermittent Joined studio review sessions. This model was to achieve reconciliation between the pedagogical principles underlying the Total and Second Studio. The objective was to encourage students to think 'technically', 'environmentally', and 'architecturally' as an integral part of architectural design, and at the same time empower students to focus on more in-depth exploration of particular aspects. Initially students will explore technical design problems in their T&E studio and the work will be assessed independently from the studio in a more focused T&E reviews each week. The T&E studio is to guide students, introduce methods of environmental design and help students gain a deeper understanding of technical issues. In the ED studio, weekly design assignments connected to their design projects assisted in students developing the skills and knowledge required to interpret the findings of the environmental design studies. At the end of each phase, students will consolidate their findings in a joint studio, where the focus is on the integration of the findings of their studies. This enables the students to explore and understand the interrelationship between the architectural and environmental dimensions of their design proposals, which had previously been explored separately.

A review of the 2 plus 1 model was conducted and the findings reveal that the model succeeded in incentivizing students to develop technical and environmental aspects of their design from the beginning. The review of the student work also indicated that the main impact of this new approach was a significant increase in integrated thinking. It was also observed that the level at which the students have incorporated structural and environmental design strategies into their overall designs has significantly increased compared to the previous year when the same module was still taught using the traditional model.

Literature on the psychology of learning suggests that people learn best when they are motivated to learn, interested in the material and need to know something in order to reach a desired end. This implies that human beings learn best when they can combine theory and abstraction with perceptual experience or reality- actually seeing, touching and acting. The necessity to know and the opportunity for perceptual reinforcement that occurs in an architectural studio provides a much better environment for learning the practical aspects of building technology than the lecture hall. This does not, however, negate the potential role of lectures in communicating theory and basic principles to students.

In architecture schools, the studio represents the prime focus of the students' attention. Information necessary for the resolution of the design problem is learned much more quickly than material taught in a more general way. Reducing the scale or complexity of a studio exercise allows for a deeper investigation of questions involving construction, ECS or structure. There is also a theory in education that the best way to train a teacher in a particular method is to teach that teacher in using that method. If valid, this axiom would give justification for the difficulties encountered in developing and implementing new programmes that place emphasize on integration of design and technics. Given the form of education experienced by most of today's design faculty (where technical subjects were taught as isolated lecture courses), the holistic approach should be difficult to implement. It might even explain some of the eagerness to retreat from accepted approaches to programmmes integration toward more traditional methods. Many architectural educators while denying a total separation would subscribe to the view of technology as "the servant of design". This asymmetrical view of *commodity, firmness and delight* is supported in the works of authors such as Ruskin and Noberg-Schulz and by other architectural theorists. This "more equal" approach to "*one architecture*" may be the most important justification for the resistance to the Total Studio concept.

2.3.3 Underpinning Concepts of Alternative Pedagogy in Structures.

From the five distinct approaches presented, a strand of underpinning concepts can be identified. Notably, the fundamental characteristics of alternative pedagogy manifest its capacity to engage students, provides a richer learning inter-phase, stimulates their interest and enthusiasm. However the notion of alternative pedagogy in itself is hinged on fundamental concepts in the learning sciences. These concepts form the foundation of alternative pedagogy in structures. These concepts can be outlined as follows:

i. Non-Verbal Thinking/ Visuo-Spatial Thinking, and
ii. The Use of Computer Aided Instruction in Understanding Structural Behaviour

(i) Non-Verbal Thinking/Visuo-Spatial Thinking

"Thinking with pictures is an essential strand in the intellectual history of technological development. Pyramids, cathedrals, and rockets exist not because of geometry, theory of structures, or thermodynamics, but because they were first a picture- literally a vision- in the minds of those who built them" (Ferguson, 1977:827). Gaining an understanding of the development of technology requires an appreciation of the role of non-verbal thought (visuo-spatial thinking) in technology. While several everyday objects have significant scientific component, their function and form, their appearance and dimensions, were determined by technologists-craftsmen, designers, inventors, and engineers- employing non-scientific modes of thought (visuo-spatial thinking).

Ferguson (1977) further observed the simultaneous process a designer undertakes in translating an idea or concept conceived in the form of a picture in his mind into a drawing that will create a similar picture in another mind and will eventually become a three-dimensional object (building, engine or any other product). The design process can therefore be seen as a sequence starting from imagination, leading to delineation and consequently resulting in fabrication or construction. While a number of design decisions such as thickness of wall, width of lobby and pin diameter may depend on scientific calculations, the 'non-scientific' component of design remains primary. It depends mostly on visuo-spatial thinking (nonverbal reasoning) of the designer, who is engaged in the process of thinking with pictures. The entirety of our technology today has a significant intellectual component that is both nonscientific and nonliterary.

Technological developments have been stimulated by many drawings and pictures. Findings from the review of the literature reveal five major strands critical to our present day technological development. These are (i) renaissance picture books, (ii) graphic inventions, (iii) object teaching, (iv) experiential learning-project based and (v) precedent learning-case study. First, during the Renaissance era (15th century), a large body of technical knowledge were recorded and conveyed in the form of drawings and pictures. Several technologists, designers, engineers and designers involved in this nonverbal mode of thought documented existing tools and machines and also compiled their thoughts, innovations and inventions in what has been known as renaissance picture books. The impact of nonverbal thought via these books was far reaching in shaping the creative process of technologists. In fact, Ferguson (1977) commented that overly complex assemblies of gears, cams, and links, have made it so easy for us to dismiss as mere fantasy, became embedded in inventive minds through repeated exposure to these machine books and their progeny. These books were so influential in transmitting technical knowledge through illustrations that some engineer's notebooks contained no text all. He further noted in the preface of a book by one of the exponents of that period called Agricola. Agricola remarked on the difficulty of describing machines and other technical matters fully and clearly. Ferguson (1977:829) observed that *"with regard to veins, tools, vessels sluices, machines, and furnaces, I have not only described them, but have also hired illustrators to delineate their forms, lest descriptions which are conveyed by words should either not be understood by men of our times, or should cause difficulty to posterity"*. It can be inferred from this submission that transmission of technical information through illustrations was fundamental to the technological developments and innovations of the renaissance era.

Second, was the revolutionizing power of *graphic inventions* in conveying greater technical knowledge, which to a great extent enhanced designers abilities as they engaged in nonverbal thought that clarified and simplified pictorial representations. These include the art of printing, techniques of pictorial perspective and the use of models. Ferguson (1977) observed that printing techniques were central to the growth of our modern technological civilization as it facilitated making of multiple identical copies and of pictorial perspective that determined the rules of realistic pictures readily understandable by craftsman and scholar alike. Leonardo da Vinci's invention of the "exploded view" helps to explain reality in a rigorous yet imaginative way. Orthographic projection, which is universally deployed in mechanical drawing, provided a medium to convey greater amount of information in three views than a perspective drawing. William Farish, of Cambridge University, in the nineteenth (19th) century introduced the isometric view, which was a modified form of pictorial perspective appropriate for drawing machine elements and subassemblies.

Another significant graphic invention in the 19th century was the ordinary graph or curve, which transforms a mathematical expression (relationship) into a visual image. It displays a curve that connects the intersections of two sets of quantities plotted along two coordinates are displayed. Changing variables are visually represented with characteristic curves describing performance of machines or materials. Farish further noted that the builders of the medieval cathedrals and castles, often employed the use of models to plan and lay out complex portions of the structures. Models were particularly helpful in determining the order of assembly of elements of masonry in vaults as well as in working out the truss arrangements in large roofs.

Third, was the introduction of *object teaching* in the 17th century by Joannes Comenius by using visual images in elementary schooling. In his little picture book, *Orbis Sensualium Pictus* published in (1658), Comenius matched objects to words. He argued that "*if a word were associated with an object or a picture, it would be more readily learned and better understood"*. He posited that that "*most minds think with pictures as well as words"* (Ferguson, 1977:832). It was remarked that Albert Einstein claimed that he rarely thought in words at all.

Fourth, is *experiential learning*. This involves the employment of hands-on-learning. This mode of thought and learning encouraged pupils to visit the workshops of craftsmen (watchmakers, goldsmiths, printers, e.t.c) in order to study their works thereby having a first-hand knowledge of the nuances and idiosyncrasies of those trades by a hands-on approach which consequently leads to experiential learning. This mode of teaching is essentially nonverbal in its approach and knowledge acquisition is basically via observation. Isaac Newton in 1669, was reported to have advised a young friend who was travelling to the continent to seek out and observe their "Trade and Arts wherein they excel or come short of in England," as well as to see what the Dutch had achieved in the grinding and polishing of "glasses plane" (Ferguson, 1977).

Fifth, is precedent study, also known as case study approach. In this approach, it was assumed that the histories of trade would encourage the invention of improvements. A large and an unbounded mind is likely to be the author of greater productions, than the calm, obscure, and fetter'd endeavours of the mechanics themselves. Nonverbal thinking characterized by visual and even tactile imagery involves perceptions attributed to the artist, and not the scientist. Noting that perceptive processes are not known to entail "hard thinking," it has been relegated among the more primitive stages in the development of cognitive processes and inferior to verbal or mathematical thought.

(ii) The Use of Computer Aided Instruction in Understanding Structural Behaviour

While the influence of Information and Communication Technologies (ICTs) is prevalent in nearly every area of our society, unfortunately, they have not yet succeeded in transforming our concepts and practices of teaching and learning (Wang, 2009). The advocates of ICT claim that, it has the power to radically change the classroom experience (Wang, 2009). At the core of this change is the relationship between the teacher and the learner. The champions of ICTs argue that their introduction, will make the complex process of learning become more interactive - that is, learner-centered instead of teacher-centered and knowledge-centered (Wang, 2009). Two recurring themes from literature on the impact of ICTs on education are that ICTs have the potential to radically transform educational practice; and consequently promote the constructivist paradigm of epistemology.

Dirckinck-Homfeld and Lorentsen (2003) have argued from their own teaching experience that ICTs do indeed have the potential to transform university education by making it truly interactive. The use of ICTs in education seeks to promote change in the direction of student-centered interactive learning (Wang, 2009). Andia (2002) observed that architectural schools have used ICT to transform both architectural imagination and architectural practical possibilities.

Three core educational values of computer analysis for teaching structures can be identified from the work of Black and Duff (1994: 45). These are:

i. *That it can speed up lengthy computations and increase analytical accuracy;*
ii. *It can provide students with a direct shortcut to gaining an understanding of structural, behavior without years of background preparation;*
iii. *The relative merits of various structural systems can be compared in real terms, and the feasibility of design ideas can be tested concretely, regardless of their complexity.*

Black and Duff (1994: 46) further reported the effects of computer analysis and simulations to include that:

i. *If intelligently guided, students can gain more direct experience of structural behavior through the use of computer analysis in a one-semester university course than they would normally get in years of practice.*
ii. *The ability of the computer to display deformed shapes rapidly allows students to study structural behavior from a kinematic point of view, rather than solely in terms of forces and load paths;*
iii. *The activity of "zooming", in which attention is repeatedly shifted between local considerations and global considerations, is practically forced on the students, as they must continually check the individual members for overstressing and buckling while they design and study the global structure;*

iv. *Students are able to study structures in the context of design, as the computer can be taken into a design setting and used as a design tool. Students then find themselves studying structures on their own turf, rather than in the alienating and isolated territory of math-oriented engineering, and can realistically consider structure and structural behavior in the earliest, inventive stages of their work. Moreover, the continuing iterative cycling and refinement of architectural ideas can be exactly paralleled to a sequence of structural analyses, and as design iterations unfold, structural analysis can continue alongside architectural design in a truly integrated fashion.*

v. *The most notable effect of using the computer in the classroom is that it really can be used as a tool for discovery, and it transforms a course from one in which students are passively receiving information and solving artificial and empty problems into one in which they are actively engaged in finding things out for themselves.*

Noting the potential of Computer Aided Instruction to transform education, instructors in architectural structures have attempted to explore this vast opportunity by developing computer aided learning packages to enhance the understanding of structural behaviour. These include computer aided drawings, sketches, pictures, use of structural analysis software (Finite Element Analysis, DEFLECT, ARCADE, CASDET), animation/interactive models, web-based, multimedia, computer generated models, multiple solutions. The use of Computer Aided Instruction in understanding structural behaviour is inherent in its potential to provide enhanced graphics through -drawings, digital pictures, digital models, simulation, structural analysis software, animation, thereby accelerating the rate of visual thinking in students which has been seen to be fundamental in comprehending technical concepts and stimulating structural creativity. An appraisal of different computer aided learning packages in understanding structural behaviour has been done in previous sections of this chapter (see section 2.3.2.2 of this thesis)

2.4 Two Novel Approaches to teaching structures

While five different alternative approaches (piecemeal forms) have been discussed in the previous sections, the next paragraphs discusses more elaborate approaches, especially models for teaching structures that have been identified in the existing published literature.

2.4.1 The Finite Element Analysis (FEA) Model For Teaching Structures

In view of the growing dissatisfaction with the conventional approach to teaching structures, Black and Duff (1996) developed a model for teaching structures using the Finite Element Analysis method. The FEA model was based on the premise that "for architects to effectively utilize these fundamentals, structures cannot exist as a separate discipline but must be approached in a manner that is always oriented toward the total design process". They identified a number of shortfalls of the conventional approach to include the following:

The conventional approach followed by engineering schools, where students master the material incrementally and only after four or five years begins to study the subtleties of structural behaviour, is in fact impossible for typical architecture students. They also argued that typical structures courses for architects have tended to be one of two types: either predominantly quantitative or predominantly qualitative. On the one hand, the survey courses aim to extract some of the "essential" material by focusing on the qualitative side of structures while glossing over the mathematics and details, with the result that students learn to "talk" structural concepts but cannot apply them. On the other hand, detail-oriented courses focus on math, with students repetitively calculating forces and stresses in static systems and designing isolated pieces of structures, under the assumption that the big picture will emerge from a study of details.

The FEA was therefore intended to show that a practical and more useful understanding of structures can be gained through a different, albeit much narrower, route with the use of modern engineering software; thus constituting an altogether a different model for teaching structures to architecture students. Black and Duff (1996:40) documented the twelve tenets of the FEA model to include:

i. *The scope of engineering material that students should encounter during their formal education must be tailored to the specific needs of architects and must be both narrower and deeper than what is often taught.*

ii. *The development of structural intuition and engineering judgment must be a concrete aim. Intuition here does not imply blind feeling, but rather a qualitative understanding of structural behavior, backed by sound quantitative theory and based on experience and experimentation.*

iii. *Structures must be taught in the context of architectural design, rather than in isolation, as the engineering skills required for architectural design are different than those required for engineering analysis.*

iv. *There are three distinct, but interdependent domains of engineering knowledge in which architecture students need to be trained in. First, general knowledge of structural systems. Second, is understanding of basic structural concepts: statics, elementary mechanics, properties of materials, loading criteria, code requirements and design procedures. Third, they need to experience the behavior of real structures for themselves and to study the relationships among structure displacements, stiffness,* *geometry, and applied forces. Any two domains on their own are of little use without the third, and students must be trained in all three concurrently.*

v. *At the crux of this model is the study of global behavior. It is an understanding of global behavior, more than anything else, that enables a designer to integrate structure and space;*

vi. *Detailed study of indeterminate structures is crucial, as it is only in indeterminate systems that subtle changes in stiffness and geometry alter the distribution of forces.*

vii. *The approach to conceptualizing structural behavior that should be developed in students is based on kinematics and deformation, rather than forces and equilibrium.*

viii. *The mental activity of simultaneously paying attention to what is happening locally (member stresses and connection design) and to what is happening globally (force distribution and structure deformations) must be explicitly developed in the thinking of students;*

ix. *The study of structures must be rooted in a general theory of structure and space in which building structure and architectural space are considered to be inseparable.*

x. *An integrated design process, whereby architectural and structural concerns are addressed simultaneously, must be explicitly taught;*

xi. *The typical relationship between course lectures and labs, in which labs are used to illustrate and enhance lectures, is in fact incorrect. Labs must be the primary component of courses, around which everything else revolves, and the main purpose of lectures should be to support and feed the activities of the labs; and*

xii. *Courses must be practical in their approach and must have a central purpose rooted in something real.*

Black and Duff (1996), noted that the FEA Model would be impossible using traditional teaching methods, noting that it is only through the use of computer analysis and simulation that this approach becomes possible. Finite Element Analysis is a powerful modern method for engineering analysis, with applications in diverse fields from structural engineering to fluid dynamics. FEA is in essence a numerical technique involving the matrix formulation and solution of a large linear system of equations. It involves the decomposition of a structure into small pieces for individual evaluation and the subsequent reassembly of the individual pieces of contributions to the behavior of the overall structure for global evaluation.

FEA is used as method of analysis in engineering but this model deploys it as a teaching tool for architectural structures. A key characteristic of the FEA lies in the untapped potential of modern computer analysis in providing students with a direct shortcut to gaining an understanding of structural behavior without years of background preparation.

The developers of the model observed that the most notable effect of using the computer in the classroom is that it really can be used like Galileo's telescope, as a tool for discovery, as it transforms a course from one in which students are passively receiving information and solving artificial and empty problems into one in which they are actively engaged in finding things out for themselves. They further asserted that the use of FEA as a tool for learning is so powerful, that it has the potential to revolutionize the instruction of structures to architecture students.

Beyond the merits of the FEA, a number of shortcomings have been noted. First, computer analysis will never remedy an ailing structures curriculum. This is a gap this study hopes to fill by identifying the relevant issues in a structures curriculum thus providing the requisite knowledge for decision making. Second, is the danger that students in a computer based structures course will focus more on the bells and whistles of the technology rather than on the underlying principles of engineering, with the consequence that the entire course degenerates into a superficial exercise in computer graphics. Third, is the inherent bias of using a structural engineering software and tool thus a barrier- language barrier still exists. Fourthly, despite the overwhelming applause for the six years usage of the FEA model (as at 1996, when it was reported) there has been no empirical data to support the claims.

2.4.2 A Comprehensive Approach to teaching Structures Using Multimedia.

The project "A Comprehensive Approach to Teaching Structures Using Multimedia" was the result of a collaborative inter-institutional, multi-disciplinary team from the University at Buffalo, State University of New York; University of Oregon and University of Utah, USA. It aimed at creating an environment for teaching and learning structures in a manner that enables understanding of basic principles, practical aspects of structural design, and the creative possibilities of applied structure. The project's team comprised: Shahin Vassigh and Dr. Scott Danford from University at Buffalo, the State University of New York; Patrick Tripeny from University of Utah, Ronald Shaeffer from Florida A&M; Christine Theodoropoulos from University of Oregon; and Edward Allen.

Vassigh (2005) noted that the project was motivated by the observation that despite the fact that understanding structures is central to the education of the architect, its "content" (theory and pedagogy) and "delivery systems" (teaching methods) currently in use are distinctly inappropriate for the vast majority of architecture students. He further observed that architecture faculty and students struggle with a traditional engineering-based approach to structures instruction, which is becoming increasingly ineffective in the classroom. The impact of this he noted was that structures in many architecture programmes were treated as the unwanted stepchild of the curriculum – viewed as difficult to teach by faculty and a complicated and uninteresting requirement for graduation by students. One of the far reaching implications of this is the failure to adequately prepare architecture graduates in structural design and applications, which creates unnecessary costs for architectural firms who have to invest in the technical training required to properly educate practicing architects in the basics of structural design.

Drawing on this motivation, the proposed strategy: Interactive Structures Software (ISS) was developed based on a pedagogy guided by the following principles:

i. *Teaching structures should facilitate understanding of fundamental principles of the practical aspects of structural design in addition to the creative capabilities of applied structure within the built environment;*
ii. *Particularly for architecture students, the instruction of structures should be visually and spatially grounded, so that it is understood as an integral part of the conceptual and theoretical aspects of design;*
iii. *Teaching tools should make the instructor more effective in the classroom, make the student a more efficient learner, and make student-faculty interaction as effective and efficient as possible; and*
iv. *Instruction should aim at increasing student interest in structural design, particularly as a lifelong learning skill* (Vassigh, 2005:136).

The project comprised of three components: the Interactive Structures Software "ISS", the instructional support center "Structures Learning Center", and student performance evaluation tools. The software explores three areas; basic concepts, structural systems and architects' modules. Each module is divided into eight sections with an average of 20 to 30 animations with fully graphical illustrations and relevant images that explain general structural analysis, concepts, definitions, working principles and architectural design issues.

While the basic concepts module comprised statics, loads, structural materials, mechanics of materials, connections, lateral supports, foundations and structure and form, the structural systems module is made up of an overview section, trusses, columns, beams, cables, arches, frames, and surface spanning elements. The architects' module features eight prominent architects with three building structures selected from each architect's work for purposes of analysis.

The instructional support website or the Structures Learning Center is the second component of the project, it has the objective of providing additional resources to students using the ISS. It is organized into three components; namely structures, resources, and ISS. While the structures component is organized into similar sections as the ISS and contains a glossary of terms and information on basic structural concepts, the resources sections contains an extensive list of books, videos, CD-ROMs, and websites relevant to structures. The key component are approximately 200 books, 100 websites, and close to 20 video/CD-ROM sources-making it one of the most comprehensive list of structures resources on the web (Vassigh, 2005). The ISS was designed to overcome the limitations of two-dimensional abstract representations of structural behavior in the traditional textbooks by providing a relatively realistic context on which structures would be taught and understood easily.

The third component of the project is Student Performance and Evaluation. This component has the goal of measuring whether the use of the ISS improved student test scores, application of structures principles to architectural design work, and whether it influenced student attitudes towards structures. The evaluation involved two groups of students- a *control group* that received traditional structures instruction not using the ISS, and an *experimental group* that received structures instruction using the ISS. The findings of the project confirms the central underlying principle of the project, which was utilizing visual techniques to improve student performance.

2.5 Relevant Concepts from the Learning Sciences

Contemporary literature in the learning sciences suggests a number of instructional techniques that can increase learning of structures. These techniques include collaboration, active learning, integration of assessment and feedback, and the use of concrete physical manipulatives, to devise a sequence of learning modules. Dollar and Steif (2008) noted that these learning strategies offered stimulating activities for the classroom that make visible the relation between forces and the object interactions they represent. In developing their interactive, cognitively informed, web-based statics course, Dollar and Steif (2008:1230) identified some relevant lessons from the learning sciences. These lessons can be summarized as follows:

i. *"Instruction in general and educational software in particular should have clearly articulated learning objectives.*
ii. *Students who are actively engaged learn more.*
iii. *Assessment should be thoroughly integrated into the learning process, with students given ample opportunity to test their knowledge and receive feedback on their progress.*
iv. *Giving students timely and targeted feedbacks improves learning and deepens understanding.*
v. *Providing hints and scaffolding on demand is a general instructional technique that allows students to progress in a task as long as they are able, and provides only what the students need should they get stuck.*

vi. *In conceptually complex domains, self-explanation is found to improve learning.*

vii. *In multimedia learning, the modality principle which states that receiving complementary information in two modalities, for example viewing diagrams and listening to an explanation, are often better than seeing the diagrams and reading the same explanation.*

viii. *Guided interactive simulations can be selectively used to explain certain concepts far more succinctly, and less ambiguously than words can. In particular they can help learners connect calculations and numbers with physical representations. For example, to explain phenomena that involve motion, including the effect of changing parameters.*

ix. *The use of manipulatives accommodates students with a greater range of learning styles".*

2.6 Conceptual Framework of the study

Theories essentially summarise and organise important facts. Fundamentally, a theory simplifies and imposes order where there might otherwise be complexity and chaos. It is also useful for predicting events as well as for explaining a phenomenon. More importantly, apart from providing satisfying explanations, theories are thought provoking. The literature is replete with several theories that guide this study. This section of the thesis attempts to explore the theories relevant to this study, that is those theories that have high heuristic value. Exploring these theories consequently leads to situating a conceptual approach to the study. Important concepts that underpin this research are also explored to further articulate a succinct approach in addressing the issues of concern in this study.

The aim of this study, which is to investigate the teaching and learning of architectural structures as a course, with a view to identify ways of improving students' interest and understanding of the course in selected universities in South-west, Nigeria revolves around two principal factors namely: ***learning inputs*** and ***learning outcomes***. Findings from the literature across architectural technology education and the learning sciences reveals a number of relevant theories and concepts. Five of these considered relevant to this study are explored in the subsequent sections. These include Constructivism, Kolbs Experiential Learning Theory (ELT), the Theory of pedagogical Praxis, Technology-Enabled Active Learning (TEAL) and Technological Pedagogical Content Knowledge (TPCK).

While a discussion of these theories and their relevance is presented below, central to this study is the concept of Technological Pedagogical Content Knowledge (TPCK) developed by Mishra and Koehler (2006), building on Schulman's classic (1987) concept of pedagogical Content knowledge (PCK). According to the proponents of the TPCK, technology, pedagogy, and content are no longer regarded as separate constructs but as one integrated knowledge base fundamental to the delivery of instruction. Thus technology, pedagogy and content, herein regarded as one integrated knowledge base fundamental to the delivery of instruction provides a framework for this study as it encapsulates possible derivatives of learning inputs, which should determine learning outcomes. The conceptual framework of this study seeks to carefully examine the impact and inter-relationship of the learning inputs on the learning outcomes in architectural structures instructions. The learning inputs (independent variables) essentially can be further broken down into three sub-variables, which are pedagogy (teaching approaches), technology and content knowledge, while the learning outcomes (dependent variable) can also be broken down into sub-variables which are structural literacy and structural competence. The students' profile is the intervening variable.

Specifically, the study examined the impact and inter-relationship of pedagogy, technology and content (learning inputs) on structural competency and structural literacy (learning outcomes). Pedagogy is the teaching approaches and students perception of these approaches. Technology is delineated as the use of ICTs instructional design and delivery, which is the learning environment. Content is the curriculum (See Table 2.1).

The teaching approaches variable has its sub-variables as lecture based instruction, project based instruction, case-based instruction and visual based instruction. The students' perception of the teaching approaches is made up of area of emphasis in teaching, relevance of structures to design studio, level of interest, student perception of teaching approach and student perception of content. The learning environment (use of ICT) is comprised of use of digital media in teaching, use of online resources, use of internet, e-learning platforms, use of structural analysis software application, social media, lecturer's website/ course website. The students profile is made up of demographics, personality characteristics and learning styles.

Table 2.1: Independent Variables Investigated for this study

S/N	INDEPENDENT VARIABLES
1.	**LEARNING INPUT**
	A. Teaching Approaches *i. Lecture Based Instruction* a. Lectures b. Tutorials *ii. Project Based Instruction* a. Group based projects b. Laboratory tests & investigations *iii. Case Based Instruction* a. Study of structural failures b. Study of historical structu res c. Case studies from practice *iv. Visual Based Instruction* a. Usage of graphic – (sketches & pictures) b. Use of models (physical, 3D computer generated models) **B.** Curriculum (content) **C.** Students Perception of Teaching Approaches i. Area of emphasis in teaching ii. Relevance of structures to Design Studio iii. Level of interest iv. Student perception of teaching Approach v. Student perception of content
2.	**LEARNING ENVIRONMENT (USE OF ICT)**
	i. Use of Digital Media/Multi-media/ Audi–visuals in teaching ii. Use of online resource materials (e-books, courseware) iii. Use of internet iv. E-learning platforms v. Use of structural Analysis & Modeling Software applications vi. Social Media – (Facebook, Tweeter, Google+, etc vii. Lecturer's website/Course website
3.	**STUDENT PROFILE**
	i. Demographics a. Level of study b. Gender c. Age group d. Student Overall Academic Performance (CGPA) *ii. Personal Profile* a. Extrovert b. Introvert c. Sensing d. Intuition *iii. Learning Style* a. Accommodator b. Diverger c. Assimilator d. Converger

Source: Author's Conception (2014)

2.6.1 The Pedagogy of Architectural Technology: Learning Styles and Learning Theories

Several educational theories regarding individual differences among learners exist (Dunn and Dunn, 1975). However relevant to architectural education are the learning theories and their associated learning styles. Literature abounds with a broad range of learning theories that can be summarized into two broad categories; Behaviourism and Cognitivist. Recent developments have suggested additional broad categories of theories, including Constructivism, humanism and brain-based learning theories. Despite these three additional broad categories, an intensive review of the literature reveals that the three additional broad categories though with their unique identities are subsets of the two broad categories of theories. For the purpose of simplicity and clarity, learning theories and their associated learning styles shall be discussed under the two broad categories of behaviourism and cognitivist theories.

Behaviourism is a theory of learning that is focused on observable behaviours and discounting any mental activity. Learning is defined simply as the acquisition of new behaviour (Pritchard, 2008). It deals with behaviour rather than thought and places emphasis on observable events such as stimuli, responses and rewards. Simply put, stimuli are conditions that lead to behaviour and responses as actual behavior. Behaviourist theories include those of Pavlov, Watson, Guthrie, Thorndike, Hull and Skinner.

Cognitivist learning theories are concerned with perception, decision making, information processing, and understanding. Cognitivist theories include those of Gestalt, Bruner and Piaget. Computer models of thinking and current investigations of memory and motivation are also cognitive.

For the purpose of this study, emphasis shall be on towards the relevant theories that have implications for design education in general and technology education in particular that have useful applications in the teaching of structures in architecture.

2.6.2 Constructivism

Constructivism is broadly categorized under the larger domain of cognitive science. Constructivists view learning as the result of mental construction as they argue that learning takes place when new information is built into and added onto an individual's current structure of knowledge, understanding and skills. According to Pritchard (2008), we learn best when we actively construct our own understanding. Constructivism emphasizes what is commonly described as types of learning outlined as: *knowledge, concepts, skills and attitudes.*

In view of the fact that constructivism may be simply summarized as: optimum learning takes place when we actively construct our own understanding, a number of relevant concepts can be identified. The identification of these concepts requires a close look at the teaching methodology of the design studio, where students' construction of their own understanding is important. This implies that the teaching methodology of design studio in the light of the constructivist approach to learning holds significant potential in achieving optimum learning in architectural structures. It may thus be concluded that:

> *On the premise that constructivism posits that optimum learning takes place when we actively construct our own understanding (Active Learning), optimum learning in structures would take place when ACTIVE LEARNING STRATEGIES (ALS) are deployed (see figure 3.1).*

From the literature several relevant active learning strategies in architectural education have been identified. However, two broad strategies (design studio methodology, technology enhanced active learning-TEAL) may be applicable here. In the light of this, it can be said that:

i. *Since constructivism posits that optimum learning takes place when we actively construct our own understanding (Active Learning), optimum learning in structures would take place when the studio based teaching (SBT) - where students construct their own understanding - is deployed (see figure 3.1).*

ii. *Further, it is also possible to say, optimum learning in structures would take place when technology enabled active learning (TEAL) - is deployed (see figure 3.1).*

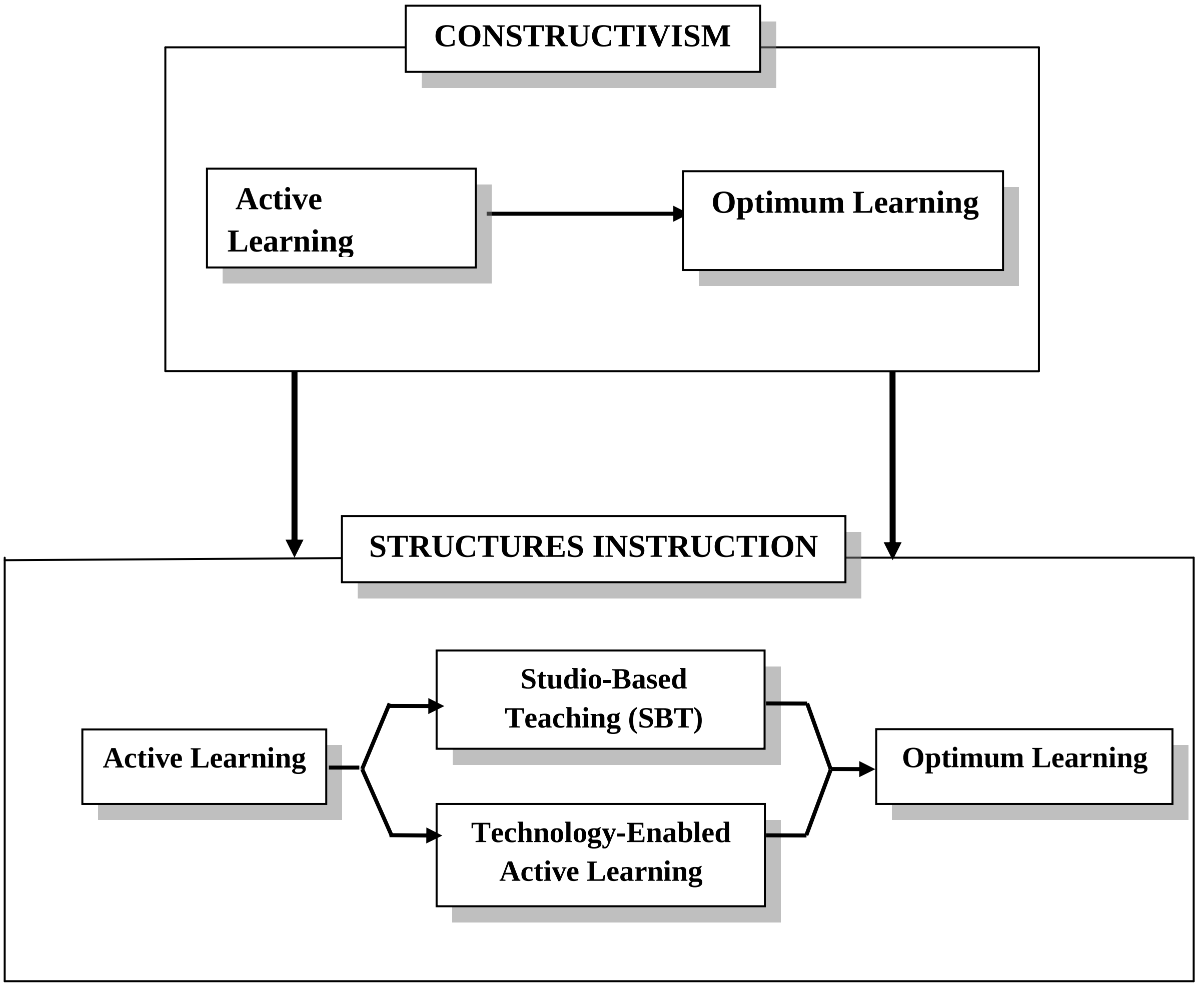

Figure 2.1: Relationship between Constructivism and Structures Instruction
Source: Researcher's conception (2016)

2.6.3 Kolbs Experiential Learning Theory (ELT)

The Kolbs Experiential Learning Theory (ELT) is the cumulative result of a number of theories such as Dewey's pragmatism(1934), Lewin's social psychology (1948), Piaget's cognitive-development (1970), Ruger's client-centred therapy, Maslow's humanism and Perls' Gestalt therapy (Demirkan and Demirbas, 2008). ELT describes learning as a cycle that starts with experience, continues with reflection and leads to action that becomes a concrete experience for reflection (Kolb, 1984). It features the four phases of the learning cycle, namely, concrete experience (CE), reflective observation (RO), abstract conceptualization (AC) and active experimentation (AE) as shown in Figure 3.2.

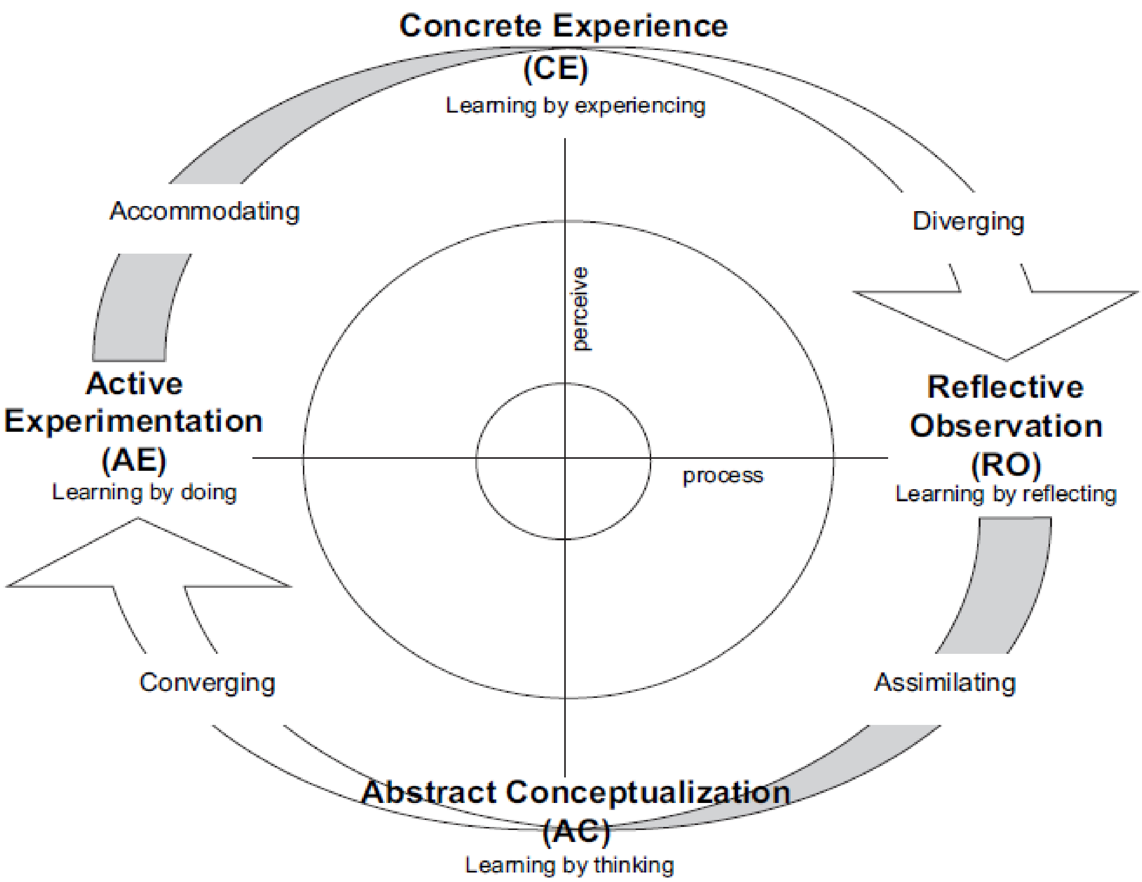

Figure 2.2 : Four Learning Phases of Experiential Learning Theory
Source: (Adapted from Kolb, 1999:4)

ELT describes two bipolar learning dimensions, namely perceiving (the vertical axis as shown above) and processing (the horizontal axis as shown above). Learners can be grouped into any of four learning styles: accommodating (CE and AE), diverging (CE and RO), converging (AC and AE) and assimilating (AC and RO), using a combination of scores on the two dimensions, as explained by Demirkan and Demirbas (2007).

Accommodating learners (Accommodators) perceive through concrete experience (CE) and process by active experimentation (AE). Accommodators are most interested in doing things (prefer learning primarily from 'hands-on' activities), and they grasp their environment concretely through their feelings and utilise action to transform information (Hsu, 1999). Furthermore, they enjoy solving problems using a trial-and –error method rather than using their analytical abilities. They are spontaneous and erratic in their approach to problem solving rather than being logical and sequential (systematic). Accomodators are people oriented and enjoy working in or as a group to achieve set goals and execute assigned tasks and often relying on others for information. They can be characterized as extroverts; and thus enjoying group projects.

Diverging learners (Divergers) perceive through concrete experience (CE) and process by reflective observation (RO). Divergers possess powerful imaginative ability and are highly emotional. They are people-oriented; and thus showing great preference for collaborative work in group projects and having the ability to create and/or assimilate various observations for new idea generation (Hsu, 1999). They are less concerned with theorems and generalizations. Their problem solving approach is not systematic; rather it is more creative in comparison to other learning styles (Demirkan and Demirbas, 2007). In addition to having broad cultural interests, they possess a broad mindset with the ability to sieve information from a wide range of sources and situations (particularly from concrete situations). They are excellent at generating new ideas.

Assimilating learners (Assimilators) perceive their environment through abstract conceptualization (AC) and process by reflective observation (RO). They experience the world symbolically, processing and converting information through thought (Demirkan and Demirbas, 2007). They are more concerned with abstract concepts rather than practical applications. They are good at devising theories. They are detail oriented. They show preference for the traditional classroom characterised by teacher centered learning of lectures, readings and love to explore analytical models. They show capacity for long-term study. They fit the model of the typical researcher.

Converging learners (Convergers) perceive through abstract conceptualization (AC) and process by active experimentation (AE). These learners bring logical, pragmatic and unemotional perceptions to the problem solving process (Hsu, 1999). They are good at integrating theory and practice. Their knowledge is well organized as they do hypothetical-deductive reasoning, while focusing on a specific problem (Smith and Kolb, 1996). They are excellent strategic thinkers. These learners prefer to experiment with new ideas, simulations and practical applications (Kolb and Kolb, 2005a). They are skill oriented.

An overview of the characteristics of each learning style is as shown in Table 3.2. The Kolb's model has a testing instrument known as the Learning Style Inventory (LSI). The LSI is a test and retest instrument that attempts to situate learners in any one or two of the learning cylces. Based on life experience and innate characteristics, individuals will develop preferences for one or two particular phases of the four in the learning cycle.

Table 2.2: Kolbs Learning Style Characteristic Description

LEARNING STYLE	LEARNING CHARACTERISTICS DESCRIPTION
Diverger	▪ Has CE and RO as dominant learning abilities ▪ Strong in imaginative ability ▪ Best at generating ideas and viewing (concrete) situations from many different perspectives ▪ Interested in people ▪ Emotional ▪ Broad cultural interests ▪ Prefer to work in groups ▪ They are less concerned with theorems and generalizations ▪ Their approach to problem solving is not systematic
Assimilator	▪ Has AC and RO as dominant learning abilities ▪ Strong ability to create theoretical models ▪ Best at understanding a wide of range of information and putting it into concise, logical form ▪ Excels in inductive reasoning ▪ Concerned with abstract concepts rather than people ▪ Prefer readings, lectures, exploring analytical models, and having time to think things through
Converger	▪ Has AC and AE as dominant learning abilities ▪ Strong in practical application of ideas ▪ Best at finding practical uses for ideas and theories ▪ Can focus on hypo-deductive reasoning on specific problems ▪ Unemotional- Logical and pragmatic in problem solving ▪ Has narrow interests ▪ Prefer to deal with technical tasks and problems rather than with social issues
Accommodator	▪ Has CE and AE as dominant learning abilities ▪ Greatest strength is doing things ▪ Strong ability to learn from primarily “hands-on”experience ▪ More of a risk taker- enjoy new and challenging experiences ▪ Performs well when required to react to immediate circumstances ▪ Solves problems intuitively- tendency to act on “gut” feelings rather than on logical analysis ▪ Prefer to work with others to get tasks done.

Source: Kolb & Kolb (2005b)

It has been advocated that Kolb's learning theory provides one of the few comprehensive and fully generalized models among the other experiential models that employ dialectic inquiry. ELT proponents base their argument on its two characteristics of having a holistic approach and being interdisciplinary. Its wide acceptance and generalised model and the Learning Style Inventory (LSI) test that provide a framework for learning in design, make ELT a useful tool for exploring design education (Kayes, 2002; Kolb and Kolb, 2005b, Demirkan and Demirbas, 2008).

Tucker (2007), relied on Webster (2001)'s observation that design teaching promotes experiential learning in much the same way as other fields of professional education to posit that Kolb's model is fitting and has therefore been utilized most commonly by researchers evaluating the learning styles of design students. Tucker (2007) also reported the conclusion of Newland et.al (1987) that the learning styles of architects are a little biased towards the upper left (north west, borrowing Talbot's (1982) visually descriptive presentation of the Kolb scores that refers to the spatial location of styles in the two-dimensional LSI cycle) of the Kolb typology. Kolb termed such learners as "accommodators", that is people with the ability to learn primarily from "hands-on" experience, and prefer "action-oriented careers" (Kolb, Boyatzis and Mainemalis, 2000). Lawson (1993) also observed that architecture students tended to adopt more intuitive approaches when engaging in design activities.

Singhasiri, Darasawang and Srimavin (2004) in their investigation of the learning styles of first-year architecture students in Thailand found that most of the students were concrete learners- that is, accommodators and divergers. From the foregoing, it can be inferred that if the learning styles of architecture students tend towards concrete approaches, then any meaningful teaching and learning (be it in design courses or technical courses – in which architectural structures is a core) that must take place must be within and tailored towards concrete approaches.

2.6.4 The Theory of Pedagogical Praxis

The theory of Pedagogical praxis suggests that new technologies make it possible to take pedagogies developed in the context of professional training-pedagogy that emphasizes participation in meaningful projects in epistemologically rich contexts – and adapting them to younger students. Pedagogical praxis indicates that students can learn effectively by engaging in computer-supported activities. These activities preserve the linkages between pedagogy and epistemology in processes by which professionals become members of their community of practice. Pedagogical praxis also argues that a critical component of such adaptations is using a computational tool to make connections from the pedagogy and epistemology of a profession to capture the interest of students, on the one hand, and to significantly transform skills, habits, and associations from a domain of inquiry such as mathematics, on the other hand (Shaffer, 2004). Shaffer (2005) reported a study on the use of the theory of pedagogical praxis in a working paper titled- "*Studio Mathematics: The Epistemology and Practice of Design Pedagogy as a Model for Mathematics Learning". That study was a summer programme in MIT Media laboratory, which was designed as a project studio-like, attempting to adapt the pedagogical and epistemological underpinnings of design practices as faithfully as possible to the intellectual and social life of adolescents and to the cognitive demands of the domain of mathematics. Students were expected to learn some mathematics after participating in 56 hours of design activity in a mathematical microworld (Shaffer, 1997, & Shaffer, 2002). Results of the study imply that design learning is a complex system and that it is perhaps more complex and more richly interdependent than has been previously acknowledged in adaptations of design practices for K-12 students in traditional subjects. The students' experience reaffirms that the practices of design can be powerful tools in supporting learning through computational microworlds. In consonance with the arguments of pedagogical praxis, the results also suggest that developers of learning environments based on design activities may need to pay careful attention to how the participant frameworks are linked to the underlying epistemology of design practices. The study concludes that as the theory of pedagogical praxis suggests, there may be critical linkages between epistemology and practice as the core of effective computer-mediated design-based learning for younger students- and perhaps as the core of effective computer-mediated learning activities based on other professions as well.

Pedagogical praxis as applied to studio mathematics, in which *design pedagogy was used as a medium in the development of mathematical understanding*, provides a veritable model for the teaching of the quantitative aspects of architectural structures that has become highly contentious (Shaffer, 2005). It is also evident that computer-mediated learning holds a lot of potentials in enhancing understanding of architectural structures, which has been corroborated by authors such as Vassigh (2005), Wang (2009), Mishra and Koehler (2006).

2.6.5 Technology-Enabled Active Learning (TEAL)

Technology-Enabled Active Learning (TEAL) was initiated at Massachusetts Institute of Technology (MIT) in 2001 and featured media-rich software for simulation and visualization to enhance students' learning (Shieh, 2012). TEAL is a pedagogical innovation established in a technology-enhanced multimedia studio that emphasizes constructivist-oriented teaching and learning. The educational theory of TEAL is embedded in the concept of social constructivist theory (Dori and Belcher, 2005). It emphasizes lively learning and small-group discussion during the instructional process. The class interaction and discussion is achieved through the support of the Interactive Response System (IRS). The IRS allows the instructor to pose questions, track and assess students' responses to the discussed questions individually. The cardinal goal of TEAL is to establish a format that engages students in learning physics and technology-related subject matters more profoundly. It is assumed that this will encourage them to acquire a more detailed understanding of the studied content, both conceptually and analytically (Belcher, 2001). TEAL incorporates lectures, problem-solving and hands-on laboratory activities in the instruction (Breslow, 2010).

The use of technology has fundamentally changed the pedagogical practices of the classroom (Shieh, 2012). Technology integration refers to the practice of engaging technology in teaching (Koehler and Mishra, 2008). Beichner *et al*., (1999) gave a report that students who were taught with a technology-rich, collaborative, activity-based instructional approach performed better those who studied with the traditional teaching method. They also discovered that students' satisfaction, confidence, and retention rates were noticeably high. Also, Hake (1998) claimed that the learning achieved by students who were taught with substantial use of interactive-engagement methods were twice as high as the one achieved by the traditional course students. Hake (2007) agreed that although high-tech per se does not ensure superior student learning, it can be beneficial when it comes to promoting interactive-engagement. Several studies (Dori and Belcher, 2005; Shieh, Chang and Liu, 2011) have particularly examined the impact of TEAL on university students studying physics courses. It was discovered that the students exposed to TEAL achieved higher learning gains than those studying in traditional classrooms (Dori and Belcher, 2005; Shieh, Chang and Liu, 2011;). Also, their retention of concept was significantly greater as noted by Dori, Hult, Breslow, and Belcher (2007).

Lowerison *et al*. (2006) argued that there was a connection between digital technology, active learning and perceived course effectiveness. Koehler and Mishra (2008) and Mishra and Koehler (2006) emphasized the need to successfully integrate technology into instruction, three types of knowledge-technology, pedagogy, and content knowledge (referred to as the TPCK framework) - to be closely connected. They argued that effective teaching with technology demands understanding the representation of problems students encounter using technologies; and the know-how of technologies to strengthen existing knowledge and to develop new epistemologies.

An examination of the relevance of the theories and concepts discussed here succinctly shows that achieving the aim of this study, which is to investigate the teaching and learning of architectural structures as a course, with a view to identifying ways of improving students' interest and understanding of the course can be achieved using them as guide or a roadmap. In the light of this, the conceptual framework of this study is presented as shown in fig 3.4

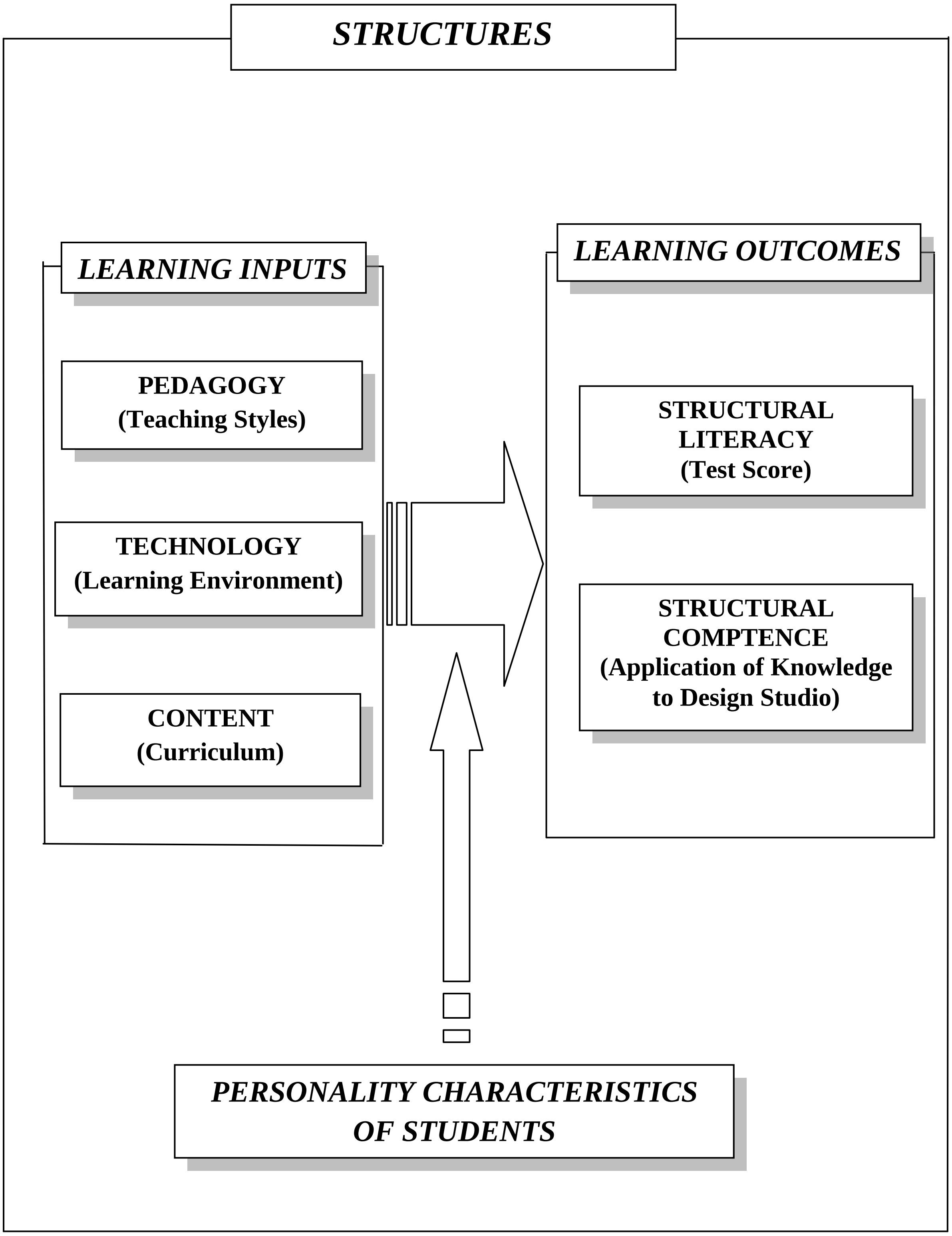

Figure 3.3: Conceptual Frame work of the study
Source: Author's Conception (2014)

2.7 Chapter Summary

This chapter of the thesis has made an attempt to identify the issues and gaps as they relate to the literature in the teaching of structures. This was achieved through the review of the existing literature on the architecture profession, pedagogy and practice, technology in architecture as in relation to architectural structures and its instruction, the approaches to teaching of structures. It also reviewed literature on the learning outcomes of the different approaches to structures instruction, and the underpinning concepts of the alternative approaches to structures instruction.

The first part of the review explored the architectural profession with respect to pedagogy and practice as the two pivots of the profession just as it is similar to other professions. The significance of pedagogy was thus established as a critical component necessary to the survival of any profession, and architecture in particular. The chapter also established the fact that the pedagogy of architecture is composed of design and technology as two parts of a whole with architectural structures a sub-component of technology. From this viewpoint the significance of structures both as a generator of form with inherent potential in determining design decisions was stressed.

The second part established the fact that there are two distinct approaches to structures instruction namely: the traditional engineering based approach and the alternative approaches. It was noted that growing students' dissatisfaction with the traditional approaches led to the development of the alternative approaches. Thus five different alternative approaches to teaching structures were identified.

The underpinning concepts of the alternative approaches were explored in the third section of the review. Visuo-spatial thinking (non-verbal thinking), computer-aided instruction, design pedagogy (experiential learning) were thus identified as the underpinning concepts of the alternative approaches to structures instruction. Identification of these three concepts provides an understanding of the workings of teaching structures that can guide this study.

The third section reviewed literature on the learning sciences. This section provided relevant lessons that further corroborated the underpinning concepts identified in section 2.3.3 and further explored two unique novel approaches in the form of teaching models. From these two models, the potential of the computer via computer-aided learning through structural analysis software, modeling and simulation in gaining deep and experiential understanding of structural behavior requisite for achieving structural competence was thus established.

From the review of literature, the following gaps were identified as follows:

i. Despite ground breaking works done in architectural education, the technical content or technology education has hardly been explored.
ii. Few empirical works have been done in the teaching of architectural structures.
iii. Few documented work (quantitative and qualitative) in Africa and Nigeria.

This study attempted to fill the identified gaps by providing empirical data on the teaching of structures, investigating the dynamics of pedagogy of structures and identifying the parameters that could be used in developing a responsive model for structures instruction for students of architecture in the selected universities in southwest Nigeria.

The final section of this chapter articulated the conceptual framework of the study. This was achieved by carefully weaving concepts and theories relevant to the aim and objectives of this study into an harmonized framework.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

A research process is aimed at finding answers to a question and is usually undertaken within a framework of a set of philosophies (approaches); procedures, methods and techniques that have been tested for their validity and reliability; and is designed to be unbiased and objective (Dawson, 2002; Kothari, 1985; Kumar, 2005). Architectural research efforts (like other research efforts) have well defined and specific objectives designed to respond to a question by adopting a credible and systematic method of inquiry appropriate and acceptable to a chosen research paradigm and consequently yielding significant results (in a thorough, documented manner which reflects a solution or eases understanding/knowledge within the research domain) (The Initiative for Architectural Research- AIA, ACSA and ARCC). The aim, objectives and research questions of this study have been outlined in chapter one. This section of the study therefore discusses the research philosophy adopted for this study expound the research approach and the research strategy, introduce the research instruments developed and utilised in pursuit of the aim and objectives of this research.

3.1 Research Philosophy

A research philosophy is simply a belief about the way in which data in relation to a phenomenon should be collected, analysed and used. It relates to the development of knowledge and the nature of that knowledge. The research philosophy adopted consists of fundamental assumptions about a researcher's perceptions and perspectives of the world. These assumptions will support the research strategy and the methods chosen as part of that strategy. Literature on the discourse on research philosophy identifies three broad research philosophies namely; positivist (often called scientific), interpretivist (also refered to as antipositivist) and pragmatism (Galliers,1991,Tashakkori and Teddlie, 1998).

Positivists perceive the world as external and objective, which is observable and describable from an objective viewpoint (Levin, 1988) (objectivist rather than subjectivist). They argue that the observer be independent from the phenomena being observed and that observations should be repeatable (validity of research findings). They adopt a value-free approach to investigation. The roles of the positivist researcher include focusing on facts and not meanings, searching out causalities and fundamental laws. Other roles of a positivist researcher include reducing phenomenon to simple elements and formulating and testing of hypothesis. Validity of knowledge (often referred to as validity of research findings) is increased by eliminating subjective biases and individual perspectives as positivists avoid being influenced by or influencing the observed phenomenon. Positivists show a preference to work with an observable social reality and geared to yield end product that can be law-like generalisations similar to those produced by the physical and natural scientists' (Remenyi *et al*., 1998:32). They make predictions and judgement based on proven facts (observed and explained realities). They are concerned with facts, rather than impressions. In positivist studies, concepts are operationalized and the methodology is highly structured so as to facilitate replication (reliability of research findings) (Gill and Johnson, 2002).

Interpretivist perceives the world as socially constructed and subjective i.e reality can be fully understood only through the subjective interpretation of and intervention in reality. The observer is seen and recognised as part of the phenomenon being observed. Interpretivists adopt a human interest driven approach (the research approach is not value-free). The responsibilities of the interpretivist researcher include focusing on meanings and not facts, seeking understanding of the meaning of events. Interpretivism also explores the totality of each individual case and develops ideas by induction from data. Key to the interpretivist epistemology is that the researcher has to adopt an empathetic stance. This involves entering the social world of the research subjects in an attempt to gain understanding of their world from their perspectives. Interpretivists argue that rich insights into this complex world are lost if such complexity is reduced entirely to a series of law-like generalisations. The interpretivists' researcher seeks to understand the differences between humans in their role as social actors.

While the discourse on research philosophy has had a competitive dimension to them, it is usually construed in terms of a choice between either positivism or the interpretivism. Pragmatists however argue that choosing between one position or the other appears unrealistic in practice. Pragmatism contends that the key determinant of the research philosophy adopted is the research question- the suitability of one approach than the other in providing answers to the given question(s). The pragmatist's believe that it is possible to work with both philosophies. That mixed methods, both qualitative and quantitative, is possible and highly appropriate within a particular study. Tashakkori and Teddlie (1998) suggest that *"it is more suitable for the researcher in a particular study to think of the adopted philosophy as a continuum rather than opposite positions"*. They noted that 'at some points the knower and the known must be interactive. In their view one should *"study what interests his/her and is of value to one, study in the different ways in which you deem appropriate, and use the results in ways that can bring about positive consequences within one' value system"* (Tashakkori and Teddlie, 1998:30). Pragmatists therefore argue that a methodology best suited to the problem under consideration, as well as the objectives of the research, should be chosen ((Benbasat, 1984; Pervan, 1994b).

This study is built on the premise that all methods are valuable if used appropriately, that research can include elements of both the positivist and interpretivist approaches, if managed carefully. Thus this study adopted the pragmatist research philosophy. The over-riding concern of this research is that the methods adopted should be both relevant to the research question, as set out in Chapter One, and rigorous in its operationalization. Both a positivist and an interpretive philosophy are required to understand the nature of the curriculum. However, a positivist philosophy is required to understand the students' profile (learning styles, personality characteristics and demographics). This research involves identifying the teaching approaches of architectural structures. This objective required a positivist philosophy in getting the students and faculty opinion as well as an interpretive philosophy by actual observation in lecture rooms to ascertain the teaching approaches. Furthermore, in order to measure the impact of technology (ICTs) on the teaching of architectural structures, a positivist philosophy is required. However, the design and development of the data collection instrument adopted a positivist, quantitative approach due to the subjectivity often associated with interpretivist research orientation.

3.2 Research Approach

Research approaches are the explicit and systematic plans and procedures of inquiry in a research ranging from broad assumptions to detailed methods of data collection, analysis, and interpretation most appropriate to the question being asked. Three major research approaches can be identified in the social and behavioural sciences namely; quantitative research, qualitative research, and mixed research. Quantitative research depends primarily on the collection of quantitative data. Being scientific it strives for objectivity, replicability and control with the aim of causal explanation and generalization. Quasi experimental research designs are usually adopted, while passive-observational designs may be accepted. A large and representative sample size is usually employed, however smaller sample sizes or single cases may be considered. Data collection and analysis must be in numerical form. That is, the phenomena of interest (e.g., perceptions, behaviours, attitudes, etc.) must be reliably measured and analysed by means of statistical analysis. Its overriding aim is to test a hypothesis derived from a theory.

Qualitative research relies on the collection of qualitative data. It is an alternative way of being scientific. "*This alternative research approach relativizes and in most cases, subverts objectivity, replicability and control. It emphasizes (inter) subjectivity, uniqueness, unrepeatability, and participation, with the aim of contextually (and eventually critically) understanding subjective perspectives and experiences. Naturalistic research designs are adopted which emphasize the necessity of studying phenomena in their naturally occurring context. Sample sizes are usually small, and single-cases are very often analysed. Data collection is done mainly in a textual or language format"* (Polkinghorne, 2005:137). Data analysis is done through content analysis-a process involving an active and transactional engagement with the collected texts (Rennie, 1998). The aim is to re-construct the personal meaning and/or experiences conveyed by the participants.

Mixed methods research is an approach to inquiry, which involves the collection of both quantitative and qualitative data, integrating them and adopting unique designs that may involve philosophical assumptions and theoretical frameworks. The main assumption of mixed methods research is that the combination of qualitative and quantitative approaches provides a more complete understanding of a research problem than either approach alone. This study aimed at investigating the teaching and learning of architectural structures as a course with a view to identifying ways of improving students' interest and understanding of the course in selected universities in Southwest, Nigeria, adopted the mixed methods research as subsequently discussed. The curriculum of architectural structures in the four selected universities was assessed qualitatively. Textual data were obtained from the student academic handbook, oral interview with faculty and students (using open ended questions). Data were analyzed by content analysis. This was done by describing and explaining the relationships in the curriculum. The teaching approaches and students' perception, the students' profiles (personality characteristics and learning styles) and their influences on learning outcomes were examined quantitatively. The degree of usage of Information Communication Technologies and its impact in the teaching and learning of architectural structures in the four universities was assessed by quantitative methods using closed ended questionnaire. The impact of learning inputs, students' profiles and the learning environment on learning outcome was investigated by quantitative methods using statistical analysis.

3.3 Research Strategy- Survey

Gleaning from the literature reviewed with respect to the research strategies used in similar studies, the research strategy adopted for this study was survey. This strategy thus resulted in the use of three main survey techniques namely: administration of questionnaires, interviews and participant observation (of students learning style and response to teaching approaches). The aim of the study was to examine the pedagogy of architectural structures in the department of architecture in four universities south-west Nigeria. Thus, the strategy for the study is exploratory and descriptive since little is known about the pedagogy of architectural structures in Nigeria. The implication of this is that while the quantitative methods may be useful to describe some characteristics of pedagogy of architectural structures, there is also a need to use qualitative method to unravel other practices and ideologies of structures instruction.

The survey strategy has been adopted because of its inherent potential to allow for inferences to be drawn about the characteristics of a population, which is a prime goal of the present study. It is preferred for a number of reasons. First, survey-generated data can be quantitatively analysed. Second, the survey method can produce a large amount of data in a short time and at a relatively low cost. Last, the survey method produces data, which can be generalized. Data for this study were collected from both primary and secondary sources. The primary data was obtained through survey of architectural students and faculty in the department of architecture in the selected universities. Questionnaires were administered in the three key areas of: technology, pedagogy-teaching styles and learning styles; and content-curriculum.

3.4 Study Population

The study population consists of all the students and faculty in NIA/ARCON accredited architecture programmes in four universities in Southwest, Nigeria. The universities are the; University of Lagos-(UNILAG), Obafemi Awolowo University (OAU), Federal University of Technology Akure (FUTA), and Covenant University (CU), Ota. These are among a total of twenty three (23) departments of architecture in Nigeria (See Table 3.3). In summary, the study population consisted of 1149 students, 60 faculty members (inclusive of 16 faculty teaching structures) and 4 heads of department. The sampling frame was made up of all the students in the 200, 300 400 levels and the M.Sc.1 who take architectural structures as a course. This is as shown in Table 3.1 below.

Table 3.1: Student Population in the Departments of Architecture in the four selected universities in South-West, Nigeria

University	**100**	***200***	***300***	***400***	***M. Sc. 1/ 500***	**M.Sc. 2**	**Total$_{ALL}$**	***Total $_{STR}$***
CU	67	*56*	*60*	*92*	*57*	41	373	***265***
FUTA	110	*118*	*102*	*108*	*94*	53	585	***381***
OAU	45	*49*	*62*	*58*	*55*	44	313	***224***
UNILAG	48	*65*	*61*	*75*	*78*	147	474	***279***
Total							1745	***1149***

Total$_{ALL}$ - Total No. of all students)
Total $_{STR}$ – Total No. of students taking structures (200,300,400, M.Sc.1)
Source: Author’s Field work (2014)

Table 3.2 : List of University with Departments of Architecture in Nigeria

S/N	University	Year Established	Accreditation Status	Ownership
1	Ahmadu Bello University, Zaira	1970	✓	Federal Govt.
2	University of Nigeria, Enugu	1972	✓	Federal Govt.
3	**University of Lagos**	**1973**	✓	**Federal Govt.**
4	**Obafemi Awolowo University, Ile-Ife**	**1982**	✓	**Federal Govt.**
5	University of Jos	1982	✓	Federal Govt.
6	River State University of Science and Technology	1982	XX	State Govt.
7	Ambrose Alli University, Ekpoma	1981	✓	State Govt.
8	**Federal University of Technology, Akure**	**1984**	✓	**Federal Govt.**
9	Abia State University, Uturu	1982	XX	State Govt.
10	Enugu State University of Technology, Enugu	1982	XX	State Govt.
11	Federal University of Technology, Minna	1984	✓	Federal Govt.
12	Abubakar Tafawa Balewa Uiversity, Bauchi	1991	XX	Federal Govt.
13	Ladoke Akintola University of Technology, Ogbomoso	1990	XX	State Govt.
14	Imo State University, Owerri	1996	XX	State Govt.
15	Federal University of Technology, Yola	1992	XX	Federal Govt.
16	Nnamdi Azikwe University Awka, Awka	2000	✓	Federal Govt.
17	Anambra State University of Technology, Uli	2002	✓	State Govt.
18	University of Uyo, UYO	2000	X	Federal Govt.
19	**Covenant University, Ota**	**2003**	✓	**Private**
20	Kano University of Science and Technology, Wudil	2004	X	State Govt.
21	Olabisi Onabanjo University, Ago Iwoye	2003	XX	State Govt.
22	Cross River University of Technology, Calabar	2004	XX	Federal Govt
23	CALEB, Imota	2011	X	Private

✓ -B.Sc & M.Sc Accredited- (Full Accreditation) – 11 Schools
X -B.Sc. Only Accredited- (Partial Accreditation)- 3 Schools
XX -B.Sc. & M.Sc Not Accredited (Not Accredited)- 9 Schools

Source: Nigerian Institute of Architects (2014)

3.5 Sampling Technique

The sampling technique that was most suitable for the study of pedagogy of structures was a hybrid of two techniques- purposive sampling and random sampling. The combination of the two techniques indicated great potential to yield a more rigorous and representative analysis. The procedure for the selection involved first purposively (non-probability) selecting of the four departments of architecture that were accredited in the four universities in Southwest Nigeria, then randomly (probability) sampling technique was used in selecting the students within the departments. The purposive sampling, which does not give each unit of the population equal chances of being selected, is used in the selection of the faculty members that teach structures in each of the departments.

3.6 Sample Size

Ideally, the sample should be representative and allow the researcher to make accurate estimates of the thoughts and behaviour of the larger population (Kumar, 2005; Dawson, 2002; Kothari, 1985;). Noting the existence of a wide array of statistical tools and formulae that could be adopted in determining the sample size, for the purpose of objectivity, a number of statistical formulas were explored and their results compared as shown

In Table 3.3. it can be said that of a study population of 1190 students assuming a confidence level of 95%, examining four different statistical formulae indicated similar results in three cases and sharp contrast in the fourth case (Survey Systems – Online resource calculator), therefore it was discarded. However, a total of 290 students was therefore adopted as the sample as it was the most occurring result from the four statistical formulae used and suitable to enable for a more representative behaviour of the larger population. The sample size for each university was also calculated using the same formula as shown in Table 3.3. For the faculty, a sample size of 32 has been adopted to give 8 faculty members per school, to include 4 structure teaching faculty and 4 non-structure teaching faculty.

Table 3.3: Determination of sample size from a population of 1190

S/N	Population	Statistical Formulae	Sample size	Confidence Level
1.	1149	***Frankfort-Nachimias et al., (1992:189)*** $n = Z^2 pq / d^2$; $n_1 = n / 1+ (n/N)$	288	95%
2.	1149	***Yamane, (1967:886)*** $n = N/ 1+N(e)^2$	299	95%
3.	1149	***Survey Systems (Online resource calculator)*** $SS= Z^2(P)(1-P)/C^2$; $SS^*=SS/1+ (SS-1)/n$	204	95%
4.	1149	***Cochran (1963:75)*** $n_0 = Z^2pq/e^2$; $n = n_0/1+(n_0 -1)/N$	290	95%

Source: Author's Research Design (2014)

Table 3.4 Calculated Sample Sizes

University	Sample Frame	Sample Size
CU	265	67
FUTA	381	95
OAU	224	56
UNILAG	279	70
Total	**1149**	**288**

Source: Author's Research Design (2014)

3.7 Unit of Analysis

The choice of students and faculty in the selected department of architecture as the unit of the study population is appropriate as the study of pedagogy of structures can be best understood from an experiential perspective in which the participants' experiences and activities is able to provide verifiable and valid data. This is consistent with the findings of the studies by Vassigh *et al.*, (2004) where students were used as the unit of analysis in evaluating a teaching methodology and Faoro (1994) in which faculty members were used as the units of analysis in a structures curriculum survey. Because of the research objectives that cut across learning styles, teaching styles and curriculum evaluation, this study used student as the unit of analysis.

3.8 Design of Data Collection Instruments

Three principal data-gathering instruments were used in the collection of the primary data for this study. They are: the questionnaire, the interview guide and observation schedule. Two sets of questionnaires were prepared by the research, one for the students (see Appendix 1) and the other for the faculty members in the departments of architecture (see Appendix 2) in the four selected universities south-west, Nigeria. The questionnaires had both closed and open-ended questions. The closed ended questions obtained precise responses while the open ended ones allowed the respondents to provide detailed answers and explanations where appropriate. For the close ended questions a 5- point Likert scale (1-5) was used as the scale of measurement. The open–ended questions provided the respondents with the opportunity to express their opinions on the subject matter investigated. The questions in the two questionnaires were arranged in sections in line with the groupings of the variables as derived from the major research issues and concepts in the study.

An interview guide was prepared for the oral interviews. It consisted of a list of questions that were asked in the interviews. This was to ensure that the same number of questions and basic issues were covered in all the interview sessions. Some of the questions were coined in a predetermined fashion. The conducted interviews followed the adoption of standardized interview format. This provided the researcher (interviewer) the freedom of probing and gauging when necessary, and to explore issues raised in the course of the interviews in a greater depth. The open-ended questions were to give the respondents an opportunity to provide detailed responses in cases where their answers cannot be easily articulated into a few words. The interview guide was designed to extract specific information unique to each school on the procedures and implementation strategies of the teaching approaches to structures. It provided additional information to compliment what was gathered through the questionnaire administered to the faculty members.

The observation schedule was prepared basically to record observations made by the researcher during the field work. Among the data this instrument was designed to collect were the modes of lecture delivery, nature of course content, classroom environment, students responses to teaching styles and others.

3.9 Data Collection and Analysis

Appropriate data collection and treatment techniques are imperative to achieving the aim and objectives of this research. A detailed methodology is therefore presented in the following paragraphs. The fieldwork for this research lasted between the months of October 2014 and December 2014, while data entering and analysis lasted between January 2015 and April 2015. Data collection was undertaken personally with the aid of four field assistants.

3.10 Data Treatment by Objectives

3.10.1 ***Objective 1*****:** Assess the curriculum of architectural structures in selected universities in Southwest, Nigeria,

Data Characteristics: The data for this objective are both qualitative and quantitative. The qualitative data describes the context, input, process and product of the structures curriculum using the stufflebeam's model. The data include course contents, credits units and course organisation. The quantitative data include students' grade. The data for the requisite structural skills of architects (structural competence) describes students' ability to use and apply knowledge acquired in structures to the design studio.

Data Source: This qualitative data on curriculum was sourced from the Nigeria Universities Commission's (NUC) Benchmark Minimum Academic Standard (BMAS) for Environmental sciences and from the academic and handbook of the selected schools of architecture. Data on peculiarities in curriculum were obtained from faculty teaching structures and Heads of the selected department of architecture through administration of questionnaires and semi-structured interviews. The quantitative data on students' grade was obtained through questionnaire.

Data Analysis: The qualitative data on curriculum was analyzed using content analysis by identifying themes and patterns. Directed content analysis procedure that employs deductive use of theory was adopted. The Stufflebeam's CIPP model (Context, Input, Process and Product) was used as the existing model for curriculum evaluation. The researcher began by reading each department's student academic handbook from beginning to end. Then, read each handbook carefully, highlighting text that appeared to describe the four components of the CIPP model. The quantitative data on students' grades were analysed through descriptive statistics (univariate analysis), means, frequencies and percentages.

***3.10.2 Objective 2*:** Examine the teaching approaches of architectural structures and students' perception of these approaches in the study area

Data Characteristics: The data for this objective are basically quantitative. This data set describes the teaching approaches, students' experiences and perceptions of structures. The data collected included frequency of usage of various teaching approaches namely, lectures, tutorials, group based projects, study of structural failures, study of historical structures, usage of graphics, use of models, case studies from practice and laboratory tests and investigations. The data on students' perception included area of emphasis in teaching, relevance of structures to design studio, level of interest in structures, teaching approaches and content.

Data Source: The data were derived both from faculty and students from the four selected department of architecture and participants observation in lectures through the questionnaire instrument.

Data Analysis: Descriptive statistics was used in analyzing the teaching approaches of architectural structures and students' perception of these approaches. On teaching approaches, respondents were asked to rate the degree of usage of specific teaching approaches on a 5-point Likert scale, where 1= Never, 2= Rarely, 3= Neutral, 4= Often, 5= Always. Students perception of teaching approaches of architectural structures was examined using the questionnaire instrument and respondents indicated their levels of agreement or otherwise with specifically outlined impressions on a 5- point Likert scale, where 1=Strongly Disagree, 2= Disagree, 3= Undecided, 4= Agree, 5= Strongly Agree. The extent to which personal experiences agree with specific statements were also examined on a 5-point Likert scale, where 1=Never, 2=Rarely, 3=Sometimes, 4=Often, 5=Always. The data obtained from the responses were subjected to descriptive statistics (Uni-Variate) analysis, which involved data grouping, computation of frequencies and percentages as well as the presentation of result using tables and charts.

3.10.3 Objective 3**:** investigate the students' profiles (personality characteristics and learning styles) and its influences on learning outcomes in architectural structures in the selected universities,

Investigate the students' profiles and its influence(s) on learning outcomes in structures.

Data Characteristics: Data for this objective are basically quantitative. This data describes three key aspects of the students' profile: demographics, personality characteristics and learning styles of architecture students in the universities. The data on demographics include gender, age groupings and academic performance (CGPA), while data on personality characteristics included orientation to life (extroversion versus introversion), and perception (sensing versus intuitive) of the Myers- Briggs Type Indicator (MBTI). Data on learning styles profile include the accommodator, diverger, converger and assimilator learning styles of the Kolbs Experiential Learning Theory (ELT).

Data Source: The data for this objective were derived from the student survey questionnaire as in objective 3.

Data Analysis: Descriptive statistics was used in analyzing the students' profiles (demographics, personality characteristics and learning styles). This involved calculation of frequencies and percentages and the presentation of the results using tables, charts and cross tabulation.

3.10.4 Objective 4: Assess the degree of usage of Information Communication Technologies and their impact in the teaching and learning of structures in the four universities sampled.

Data Characteristics: The data for this objective is mainly quantitative. This data set measures the extent of the usage of information Communication Technologies. Such data include use of the Internet, use of structural analysis and modeling software applications, use of digital media (multi-media/audio-visuals) in teaching, lecturer's website, e-learning platforms, use of online resource materials (e-books, courseware), social media (facebook, tweeter, google^{+}, etc).

Data Source: Data required for assessing the degree of usage of Information Communication Technologies was derived from the students questionnaires and semi-structured interviews.

Data Analysis: The quantitative data obtained from the respondents were on a 5-point Likert scale graduated as 1= Never, 2=Rarely, 3=Neutral, 4=Often, 5=Always. Data obtained was subjected to descriptive statistics, which involved calculation of frequencies and percentages to know the distribution of overall respondents rating on all the ICTs tools assessed.

***3.10.5 Objective 5*:** Investigate the influence of learning inputs, students' profiles and the learning environment on learning outcomes of structures in the selected universities.

Data Characteristics: Data for assessing the influence of learning inputs, students' profile and the learning environment are mainly quantitative in nature. The data on learning inputs include teaching approaches, curriculum and students' perception, while the learning environment is essentially the use of ICTs. Data on Students profile include demographics, personality characteristics and learning styles. Breakdown of the subcomponents of the factors is as shown in Table 3.1. The data on learning outcomes is in two dimensions; structural literacy measured by the students' grades and structural competence measured by the students' ability to apply knowledge gained in structures to the design studio (the core of architecture education).

Data Source: The data for this objective was derived mainly from the students and faculty survey questionnaires and interviews.

Data Analysis: The data obtained were analyzed using categorical regression (CATREG) analysis. For CATREG analysis, learning outcome was used as the dependent variable, and the analysis involved regressing learning outcome (dependent variable) with learning inputs, students' profile and learning environment as the independent (predictor) variables.

3.11 Data Processing

Data processing and analysis were carried out using computer and the Statistical Package for Social Sciences (SPSS) 20 for windows, while a non-statistical analytical tool such as content analysis was used for the qualitative data derived mainly from the interviews conducted and observations. Analyses of responses and observations were to identify common themes and trends in the subject investigated.

Table 3.5: Distribution of questionnaire across the four universities surveyed

University	Sample Frame	Calculated Sample size	Number of questionnaire distributed	Number of duly completed questionnaire	Percentage of retrieved valid questionnaire
CU	265	67	100	94	94.00
FUTA	381	95	120	83	69.17
OAU	224	56	80	74	92.50
UNILAG	279	70	100	58	58.00
Total	**1149**	**288**	**400**	**309**	**77.25**

Source: Author's Field work (2014)

3.12 Reliability and Validity Tests

Reliability and validity are the two most important concerns in research design, methodology, results and findings. Reliability refers to the repeatability of findings. Validity refers to the credibility or believability of the research. One of the validity test carried out was the pretesting of the questionnaires among students and faculty of Bells University and Covenant University (10 questionnaire each, making a total of 20). The reliability test included the use of a 5 point Likert scale to assess personality characteristics, learning styles students' perception of structures on a rating by respondents where No Response = 0, Strongly Disagree = 1, Disagree = 2, Undecided= 3, Agree= 4, Strongly Agree = 5. Degree of usage of specific teaching approaches and usage of ICTs were assessed on a rating by respondents where No Response = 0, Never = 1, Rarely = 2, Neutral = 3, Often = 4, Always = 5. The reliability (repeatability) or internal consistency of the above scales is of great significance to this study. The Cronbach's alpha coefficient test conducted on the 91 variables used to investigate Objectives 2-5 of this study showed high Cronbach's Alpha of 0.891. This value is more than the recommended minimum 0.7 alpha value. This result therefore shows good internal consistency of the scale of measurement, and thus the scales of measurement for this study are reliable with the sample.

3.13 Summary

This chapter, which had the aim of discussing the research methodology, outlined and described the stage-by-stage method adopted in carrying out this research. It is clearly seen in this chapter that both qualitative and the survey research methods were adopted for the study. For the purpose of data collection, the sample frame consisted of 1149 students from the 4 accredited schools of architecture in South-West, whereas the sample size (determined by a combination of several statistical formulae) consisted of 288 students. A combination of questionnaire, oral interview and observation schedule was used as data collection instruments. The collected data was processed and analyzed using computer and SPSS 20 for windows. The analysis was based on three broad categories of variables, learning inputs, learning environment and students' profile. The data collected were then analysed by a variety of statistical tests, descriptive statistics (frequencies, percentages and proportion) and inferential statistical test (categorical regression analysis-CATREG). Subsequent chapters of this thesis presents the results of the analyses and tests as well as their implications.

CHAPTER FOUR

PRESENTATION OF RESULTS

4.0 Introduction

The aim of this chapter is to present and interpret the results and analysis of this study. The chapter is divided into five main segments in line with the five objectives of the study. The first, presents and discusses the results of the data on the review of the curriculum of structures across the four schools surveyed. The second presents and discusses the results of the data on the teaching approaches (and students perceptions) and profiles of faculty (educational qualification, teaching experience, professional background, and others). The third segment presents the results and analysis of the findings on students' profile (demographics, personality profiles and learning styles). Results and analysis of the findings on assessment of the use of Information Communication Technologies (ICTs) is presented in the fourth segment. The fifth presents the results and analysis of findings on the impact of learning inputs, students' profiles and the learning environment on learning outcome. The chapter ends with a summary of the key findings.

4.1.0 Evaluation of the Curricula of Architecture Programs In The Selected Universities

Curriculum evaluation has been described as: "*the assessment of the merit and worth of a program of studies, a field of study, or a course of study" (*Glatthorn, *et al.*, 2012). Guba and Lincoln (1981) have distinguished merit and worth in the following ways: **Merit** refers to the intrinsic value of an entity, that is, the value that is implicit, inherent, and independent of any applications. This implies that merit is established without reference to a context. **Worth** on the other hand, refers to the value of an entity with reference to a particular context or a specific application. It is the "payoff" value for a given institution or group of people. It is therefore in the light of both "merit and worth" that the structures curricula were evaluated in this chapter. In view of the fact that these two concepts form the fundamental rubrics of curriculum evaluation, it is pertinent to note that several models of curriculum evaluation have been developed over the years. These include Bradley's Effectiveness Model, Tyler's objectives-centered model, Stufflebeam's context, input, process, product model, Scriven's goal-free model, Stake's responsive model and Eisner's connoisseurship model. Though each of these models has its criticisms and strengths, the Stufflebeam's *Context, Input, Process, Product (CIPP)* model has been adopted for in this study for its methodical approach, conciseness and its emphasis on decision making, which make it appropriate for administrators concerned with improving education curricula. The CIPP model was also adopted in this study as it fits into the key issues investigated in the current research as shown in Table 4.1

Table 4.1: Adapted Form of the Stufflebeam's (CIPP) Model in evaluating Architectural Structures Curriculum

Component	Parameters
Context	An overview of Architectural Education, Technology education in architectural education.
Input	Evaluation of Course Content, Sequence and emphasis
Process	An overview of its credit units system by year of study and relative weight in the general architecture curriculum, Instructional delivery strategies and assessment method(s)
Product	Students Learning Outcomes were evaluated both by assessment scores and higher order skills (i.e outcomes that are not easily measured by tests-structural competence as measured by structural intuition).

Source: Author's Adoption of the CIPP Model (Glatthorn, *et al.*, 2012)

4.1.1 Context Dimension of the Curriculum

This study evaluated the context component of the architectural structures curricula as a course of study by examining the field of study of architecture in Nigeria. Architectural Education in Nigeria is regulated on a dual platforms by the National Universities Commission (NUC) and the Architects Registration Council of Nigeria (ARCON) and the Nigerian Institute of Architects (NIA). The NUC executes her regulatory role essentially by providing the benchmark of minimum academic standards often referred to as NUC-BMAS and conducting accreditation visits to ensure compliance with the benchmarks. On the other hand, the ARCON/NIA principally oversees compliance with professional practice requirements. For the purpose of this study the NUC-BMAS has been adopted due to its role in stipulating minimum academic standards. The Philosophy and Objectives of Architectural Education, Aims and Objectives of Architectural Education Programmes, Learning Outcomes: Regime of Subject Knowledge, and Graduation Benchmark for Architecture were examined. The findings are discussed in the next section of this thesis.

(i) Philosophy and Objectives in Architectural Education

Presented in the following sections are the critical components of the NUC-BMAS as they relate to architectural education in Nigeria. The overall national philosophy of architectural education can be stated in general terms as follows:

i. The level of exposure and scope of the programmes in a school of architecture should produce competent, skilled and versatile individuals who will be capable of facing a broad spectrum of challenges of the environment, for human and other activities;

ii. Every school should aim at exploring the rich cultural and traditional architectural resources in the country, in general and within its immediate environment in particular;

iii. Architectural schools should identify and understand the environmental problems of their communities and make great efforts towards proffering solutions to these problems;

iv. A graduate of architecture should therefore be trained in the art and science of planning, design, erection, commissioning, maintenance, management and co-ordination of allied professional inputs in the development of the environment;

v. The development of courses should be made flexible so as to allow for the changing needs of architectural education arising from changing social, economic, psychological and technological environment (NUC-BMAS, 2007).

(ii) Aims and Objectives of Architectural Education Programmes

An Architectural Education programme should be committed to:

a) A high level of quality professional education aimed at producing Architects capable of understanding and solving complex technical and environmental problems as well as applying the working knowledge to tackle and co-ordinate other related professional inputs in the development of the environment;

b) Infusing into students an understanding of the context of the design and construction in physical, cultural, social, economic and technological terms;

c) Equipping students with adequate knowledge, creativity, specialised skills and leadership capabilities. This will enable the graduate to co-ordinate and control the design and construction processes and inputs thereto by allied professionals and executors;

d) Training graduate Architect to be a consultant capable of undertaking:

i) Brief development and feasibility studies;

ii) Project initiation and development;

• Making a Professional Architect, capable of undertaking the whole range of architectural design activities from schematic design through working drawing to construction detailing and workshops drawing production.

• Providing the student with the required knowledge and skills to undertake a wide range of management activities such as coordinating site meeting, site management, facilities management, post construction evaluation, etc.

• Providing the student with the required knowledge and skill base from which he/she can proceed to further studies in architecture or related areas.

• Provide the student with entrepreneurial knowledge and skills to enable him/her to be self-reliant.

(iii) Learning Outcomes: Regime of Subject Knowledge

Each Department of Architecture providing a Bachelor degree programme is free to decide on the content, nature and organisation of its courses or modules to reflect their own peculiar characteristics. The over 150 course titles offered in the Departments of Architecture in Nigerian Universities fall within eight instructional modules. It is expected that all programmes will ensure that students are instructed in the main aspects of Architecture including the following:

a) Architectural Design

b) Communication Skills

c) History and Theoretical Studies

d) Building Construction Technology

e) Arts and Humanities

f) Environmental Services

g) Physical Sciences and Information Technology

h) Management Studies and Entrepreneurship Studies.

(iv) Building Construction Technology (Module D)

Structures as a course of study is domiciled under the building construction technology module, which is also generally referred to as technology or the technical component of architecture. According to the NUC-BMAS, The objectives of the building construction technology module are to:

i. enlarge the understanding of components of buildings, the structure and the process involved in putting them together to realise an architectural piece;

ii. enlarge the understanding the structural and constructional application of timber, masonry, reinforced concrete, steel, aluminium, as well as local traditional materials units within this module, and

iii. enlarge an understanding of implementation, cost implication, managerial, as well as various processes involved that go into realising an architect's concept.

(v) Graduation Benchmark for Architecture

The graduation benchmark (course requirement for award of degree) for the architecture programme in the four universities surveyed for the undergraduate (B.Sc) and postgraduate (M.Sc) was examined. Noting that NUC regulates architectural education in Nigeria, its standards referred to as the NUC-BMAS, was used as a yardstick in examining the benchmark for the four universities surveyed. The data for NUC graduation benchmark was derived from the NUC-BMAS (2007) document, while that of the universities was derived from their respective Departmental Handbooks. The findings, presented in Table 4.2 shows that the NUC stipulates a minimum of 219 credit units, CU has 262 credit units, FUTA has 236 credit units, OAU has 226 credit units and UNILAG has 225 credit units for graduation. An examination of the requirements shows that all the four universities are fully compliant with the NUC-BMAS.

Table 4.2: Distribution of Graduation Benchmark for Architecture

YEAR OF STUDY	CREDIT UNITS BY UNIVERSITIES				
	NUC	**CU**	**FUTA**	**OAU**	**UNILAG**
Year 1 (B.sc)	36	44	45	43	32
Year 2 (B.sc)	40	45	39	40	36
Year 3 (B.sc)	38	47	45	38	27
Year 4 (B.sc)	40	39	33	39	44
Year 5 (M. Sc)	34	45	38	36	50
Year 6 (M.Sc)	31	42	36	30	36
TOTAL	**219**	**262**	**236**	**226**	**225**

Source: Author's Field work (2014)

(vi) Variance and Deviation of the Departments from the NUC Graduation Benchmark

The study examined the degree of compliance with or deviation of the four departments from the NUC-BMAS. It was of interest to the study to find out the degree of similarities or differences in the global framework of the curriculum across the departments surveyed. Table 4.3 presents the deviation of the four universities surveyed from the NUC-BMAS for architecture programmes.

Table 4.3: Deviation from Graduation Benchmark

	CREDIT UNITS				
	NUC	**CU**	**FUTA**	**OAU**	**UNILAG**
Total Credit Units	219	262	236	226	225
Deviation by units	NA	+43	+17	+7	+6
Deviation Index	**NA**	**+ 0.1963**	**+0.0776**	**+0.0320**	**+0.0274**
Percentage Deviation	**NA**	**+ 19.63%**	**+7.76%**	**+3.20%**	**+2.74%**

Source: Author's Field work (2014)

The percentage deviation of CU is +19.63% and FUTA is +7.76%, while that of OAU is + 3.20% and UNILAG is +2.74%. A critical look at the results show that the curriculum of OAU and UNILAG are just relatively higher than the NUC-BMAS, while that of FUTA and CU are significantly higher in terms of Total Credit units for architectural structures. It is important to note that the observed situation in CU shows a marked increase from the NUC-BMAS.

4.1.2 Input Dimension of the Curricula

The input dimension of the curricula was examined under three sub-themes namely; the content, the sequence of the thematic areas and the emphasis of the curricula. The findings are presented in the subsequent section.

(i) The Content of the Curricula

The detailed course description derived from the respective academic handbooks of the four Departments surveyed is presented in this thesis. In line with the objectives the current study, the NUC-BMAS was used in benchmarking the data from the four universities. The NUC curriculum in appendix 4 and Table 4.3 appears broad (not detailed and specific) thus leaving room for subjective interpretation of the benchmark by the different universities. While it is understood that the BMAS is only a benchmark, which can only be exceeded and not reduced, and that each respective university is expected to tailor her programmes according to her philosophy, it is expected that the fundamentals are the same across the four schools. Its key themes include statics, strength of materials, structural design of reinforced concrete, timer and steel, and approximate analyses.

The curriculum of CU in appendix 5 and Table 4.3 appears to be very detailed. A close comparison with other universities indicates that it is the most detailed in content and scope of coverage as it provides explicit coverage of fundamentals of structural design. Its key themes range from an overview of structures; statics; strength of materials; structural analysis; structural design of reinforced concrete; steel and timber; to structural aesthetics and the relationship between structure and form as dictated by materials and technology. The curriculum of OAU (appendix 7 and Table 4.3) has a very strong similarity with that of CU (appendix 7) in its scope and depth of coverage. A key difference can be found in the initial themes. While the CU curriculum commences with an overview of structures and statics, OAU commences right away with Statics. OAU also differed by devoting a segment of her curriculum to structural form. In the same vein, CU devoted one of her commencing semesters to the evolution of structural forms. The key themes of OAU curriculum include statics, strength of materials, structural forms, structural analysis and structural design. It was also observed that both OAU and CU cover the breadth of the curriculum over a period of 6 semesters (3 years) and 7 semesters (3 ½ years) respectively, and thus CU and OAU have the longest duration for the study of architectural structures as a course among the four universities sampled.

An examination of the data also shows that FUTA and UNILAG have strong similarities in their content as shown in appendix 6 and appendix 8, respectively. The curricula show a degree of brevity and conciseness. Their key themes range from structural potentials of materials, strength of materials, structural analysis, structural design of reinforced concrete, to timber and steel. The curricula of FUTA and UNILAG start with the relationship between architectural form and structures, followed by strength of materials, structural analysis and design and concludes with the behaviour of structural systems and construction methods of contemporary structures. Another area of similarity between FUTA and UNILAG is in the duration of study. The two universities cover the breadth of their structures curriculum in 5 semesters with 2 credit units of for each semester translating to a total of 10 credits. Comparing the 5 semesters (a total of 10 units) of FUTA and UNILAG to the 6 semesters (17 units) and 7 semesters (18 units) for OAU and CU, respectively, it is evident that the curriculum of FUTA and UNILAG is characterised by brevity, while that of CU and OAU is characterised by depth and thoroughness of scope.

(ii) The Sequence of the Curriculum

Table 4.4 shows the distribution of the sequence of the themes and key topics in the architectural structures curriculum across the four universities and benchmarked with the NUC-BMAS. An examination of the respective course contents shows a slight variations. However a common trend in the sequence can be seen. It was observed that the sequence of the curriculum is as follows: a brief overview of structures, statics, and strength of materials, structural analysis and structural design (of reinforced concrete, timber and steel), relationship between structural behavior and architectural form. The observed sequence, which is common to all the four universities surveyed emanated from the NUC-BMAS that provided the benchmark for architectural education in Nigeria. While underscoring the sequence of the structures curriculum in the four universities surveyed, it is significant to note that it originated from the pedagogical shift from the Beaux Arts to the Bauhaus tradition, which took place between 1925 and 1950. Hedges (2014) citing Kamphoefner (1958) noted that the Beaux Art education focused on the rendered drawing of the façade with the students being informed to "ignore the structure", as this would be accomplished by others. Architectural Structures pedagogy witnessed a transformation as Walter Gropius came to Harvard University. The Schools had been re-thinking (considering plans to review) their programmes to bring mathematics, mechanics and the science of structure into focus and a clearer relationship with the design of space. The education that supported modern architecture brought mathematics in the structures curriculum. It also brought forth enduring pedagogical discourse.

The impact of the current structures sequence began to be echoed by a 1976 ad hoc committee formed by the American Collegiate Schools of Architecture (ACSA) based on their frustrations of structures pedagogy. In a memo from one of the members Richard Bender, the committee commented on the structures sequence as thus:

> *"The classical sequence of presenting physics, statics, and strength of materials, analysis and "design" may represent a logical progression of information. However, divorced as it usually is from involvement with the total process of design, this sequence has resulted in architectural graduates who have no understanding of the basic principles involved, cannot apply them, nor retain for a significant period after graduation the basic core of material encountered"*, (Richard Bender, 1976 cited by Black and Duff, 1994:39).

A fundamental concern of the committee was that architectural structures pedagogy emanated from engineering programmes without a connection to the total process of design. The conventional approach followed by the engineering schools, where students master the material incrementally and only after four or five years begin to study the subtleties of structural behaviour, is in fact impossible for the architecture students (Black and Duff, 1994). Unfortunately, the present programmes in architectural structures are usually derivatives of traditional teaching methods and conceptions that originated from civil engineering schools. As such they are not conceived, developed or taught as programmes targeted at architects and architectural needs. More often than not, they are watered-down civil engineering programs, too weak to satisfy technical requirements and ill-conceived for other objectives as Black and Duff (1994) pointed out.

In an attempt to address the impacts of the classic sequence of structures curriculum, Black and Duff (1994) proposed a Finite Element Analysis model for teaching structures that has at its foundation on the study of global behaviour. They noted that it is an understanding of global behaviour, more than anything else (the incremental mastery of structures, without an

Table 4.4 Summary of Sequence of Structures Curriculum by Themes and Key Topics

Year	NUC	CU	FUTA	OAU	UNILAG
200 level 1st Semester	Statics Strength of materials	Overview of Structures. Statics	Structural potential of materials. Strength of materials	Statics	Relationship between architectural form and structures
200 level 2nd Semester	Strength of materials	Strength of materials	Structural analysis	Strength of materials	Strength of materials
300 level 1st Semester	Structural Design	Structural Analysis	Structural design (Reinforced concrete)	Structural forms	Structural analysis and Design
300 level 2nd Semester	Structural Design	Structural Design (Reinforced concrete)	NA	Structural Analysis	NA
400 level 1st Semester	Approximate Analysis	Structural Design (Reinforced concrete	Structural Design (Steel and Timber)	Structural analysis and Design	Structural analysis and Design
400 level 2nd Semester	Relationship between structural behavior and structural form.	Structural Design (Steel and Timber)		Structural Analysis and Design	NA
M. Sc	NA	Principles of Structural aesthetics. Relationship between structure and form as dictated by material and technology			Behaviour of structural systems and construction methods of contemporary structures

Source: Author's Field work (2014)

understanding of structural behaviour) that enables a designer to integrate structure and space. Understanding global behaviour is the key link between a qualitative understanding of structural systems and a quantitative understanding of structural details. That is what makes engineering come alive and gives an architect the ability to wield structure creatively. While empirical data for the impact of the model were not provided, Black and Duff (1994) noted that student's interest in structures blossomed over a six-year period of adopting the model. They also noted that enrollment in advanced structures courses increased by 700 percent.

The findings of a recent study by Hedges (2014) also attempted to draw attention to the sequence of the structures curriculum. That study observed that structures education is generally a linear progression from mathematics, physics, rigid body statics, mechanics of deformable bodies, structural materials design and analysis, to lateral forces and overall building behaviour. The gradual acquisition of knowledge is suitable for the engineering schemata rather than the architecture schemata. To this end, an attempt at developing a new way of thinking about this current problem and exploring a structures pedagogy that is consistent with the mental framework of architecture students was made.

Hedges (2014) further noted that educators regularly model structures using a bottom-up approach through the gradual attainment of prerequisite knowledge, which follows the older associationist-behaviorist paradigm. In the most recent cognitive paradigm, scientific psychologists recognize that the mental framework, or schemata of the learner, supersedes the prerequisite knowledge. The cognitive paradigm suggests that clear information precedes the discovery of implicit knowledge in a top-down approach, in union with life experiences inside the architecture studio culture. The studio project engages the *parti pris* process that begins with a central big idea prior to its refinement. A need exists to discover a pedagogy that commences with the central idea of architectural structures (Hedges, 2014). On this premise Hedges proposed a new approach-the *parti pris* pedagogy- for a structures pedagogy that reverses the content sequence in line with the architecture student schemata in an introductory architectural structures course. He tested the parti pris model with thirty-one second year architecture students. The findings of his research from a quantitative analysis of unobtrusive data indicate that the *parti pris* pedagogy improved student performance in non-graphical multiple-choice examinations.

From the foregoing it can be seen that the observed trend of the sequence of structures curriculum that is typical of the classical structures sequence suggests a need for a rethink. The ACSA first pointed out the seeming adverse effects of this sequence, and the findings of Black and Duff (1994) and Hedges (2014) that focused on the study of global behaviour (as against component member behaviour) and the parti pris pedagogy with a focus on the concept of central idea, respectively. This is against the incremental mastery and gradual accrual of structural knowledge that is independent and disconnected from its purpose of complementing the architectural design process.

(iii) Emphasis of the Curriculum

An examination of the architectural structures curricula in the four universities surveyed reveals two key issues. First, there is emphasis on theoretical and abstract concepts; and secondly, the curricula emphasize calculations. The key finding here is that it is mostly theoretical and calculation-based with little or no relevance and application to the architectural design process. As Black and Duff (1994) noted that typical structures courses for architects have tended to be of two types: either predominantly quantitative or predominantly qualitative. On the one hand, survey courses (theory based) aim to extract some of the "essential" material by focusing on the qualitative side of structures while glossing over the mathematics and details, with the result that students learn to "talk" structural concepts but cannot apply them. On the other hand, detail-oriented courses focus on maths, with students repeatedly calculating forces and stresses in static systems and designing isolated pieces of structures, under the assumption that the big picture will emerge. In this case, however, without the breadth and depth of several years of rigorous engineering coursework, students' learned ability to draw force diagrams and calculate stresses become a narrow exercise with limited practical use in architectural design works.

It is interesting to note that Black and Duff's (1994) analogy as previously discussed to some extent is in tandem with the findings from the four universities surveyed. The curriculum of FUTA and UNILAG with a total of 10 credit units across 4 semesters and 5 semesters respectively, as compared to CU and OAU with a total of 17 credit units and 18 credit units, across 7 semesters and 6 semesters, respectively, suggest that both the FUTA and UNILAG have curricula that are about 55% in credit units compared to that of the CU and OAU. This may suggest that CU and OAU cover a great depth in their curriculum (emphasizing quantitative approaches over qualitative approaches), while FUTA and UNILAG cover less depth in their curriculum with emphasis on qualitative approaches over with quantitative approaches. The findings on the emphasis of the structures curricula across the four universities can also be situated within the context of a counterpoint dimension of the polarities of teaching structures as posited by Allen (1992:1) and shown in Table 4.5 From Table 4.10, it can be inferred that the FUTA and UNILAG curriculum appears to be inclined towards the architecture polarity while the CU and OAU appears to be inclined towards the engineering polarity at least to some extent.

Table 4.5: The polarities of teaching structures: (a) architecture; and (b) engineering

Polarity A	**Polarity B**
We spend far too much time teaching calculations, which are the least important thing about structural design. It's much more important that students learn real-world structural concepts and develop structural intuition. *We should spend much more time teaching students to select an appropriate structural material and system for any building, lay out the system in away that works well with the building's form and space, and assign approximate sizes to the structural members. The exact sizing of the members will be done mostly by engineers and computers in the real world, so architecture students need be taught only a basic repertoire of calculations.*	***The mathematical underpinnings of structural design are wonderfully elegant and clear. They give us an ideal way of unraveling the mysteries of structural behavior and developing in students an intuitive sense of how structures work.*** *They lead naturally to consideration of detailed design calculations in all structural materials. This prepares students to perform well on the architectural registration exam. It also prepares them to communicate with structural engineers in their own language. The teaching of a field so precise as structures should not be diluted with rough approximations and fuzzy conceptualizations.*

Source : Allen (1992:1)

Having examined the findings on the areas of emphasis of structures curricula with respect to the two analogies of Black and Duff (1994) and Allen (1992), it is evident that there is a divide on the appropriate architectural structures pedagogy. The impact of this divide was succinctly captured by Black and Duff (1994:40) who noted that *"either way, the end result* *has been that graduating students have no meaningful understanding of structural behavior, have little practical knowledge to apply as professionals, and are thus forced to concede all but elementary structural matters to engineers. Under these conditions, an architect is unable to elevate structure to the level of a major design determinant, alongside formal and programmatic considerations".*

4.1.3 The Process Dimension of the Structures Curriculum

In exploring the Stufflebeam's model of curriculum evaluation also known as the *Context, Input, Process, Product (CIPP)* model, the process dimension is examined in the subsequent sections. The requisite structures course credit units system and graduation benchmark were examined. The relative weight of the structures credit units in the overall graduation benchmark for architecture was examined across the four universities surveyed and benchmarked with the NUC-BMAS.

(i) Requisite Structures Course Credit Units

A comparison of the requisite credit units for structures is as presented in Table 4.6. The comparison was done by sourcing the required information from the student handbook of the respective universities. The comparison shows that the NUC-BMAS stipulates a total of 15 credit units spread across 7 semesters, with 2 units each for 6 semesters and 3 units for 1 semester. CU has a total of 17 credits units spread across 7 semesters with 2 units each for 4 semesters and 3 units each for 3 semesters. FUTA has a total of 10 units across 4 semesters, with 2 units each for 2 semesters and 3 units each for 2 other semesters. OAU has a total of 18 credits units spread across 6 semesters with 3 units each for all the 6 semesters. UNILAG has a total of 10 units across 5 semesters, with 2 units each for all the 5 semesters.

Table 4.6: Distribution of Requisite Structures Course Credit Units

YEAR	NUC		CU		FUTA		OAU		UNILAG	
	SEMESTER									
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Year 1 (B.Sc)	-	-	-	-	-	-	-	-	-	-
Year 2 (B.Sc)	2	2	2	2	2	2	3	3	2	2
Year 3 (B.Sc)	2	2	2	2	-	3	3	3	2	-
Year 4 (B.Sc)	2	2	3	3	3	-	3	3	2	-
Year 5 (M.Sc)	3	-	3	-	-	-	-	-	2	-
Year 6 (M.Sc)	-	-	-	-	-	-	-	-	-	-
TOTAL	**15**		**17**		**10**		**18**		**10**	

Source: Author's Field work (2014)

(viii) Deviation of Schools from the NUC Graduation Benchmark in Structures

The data in Table 4.7 shows the deviation of the total structures credit unit from the NUC-BMAS across the four universities. An examination of the data indicates that CU has a deviation index of +0.1333 (13.13%), FUTA has – 0.3333 (-33.33%), OAU has +0.2000 (20.00%) and UNILAG has - 0.3333 (-33.33%). It can be observed that CU and OAU have relatively closer positive deviation index suggesting a relative similarity in their curriculum at least by credit units.

Table 4.7: Deviation of Structures Credit Units from the NUC-BMAS

	NUC	CU	FUTA	OAU	UNILAG
Total Credit Units	15	17	10	18	10
Deviation by units	NA	+2	-5	+3	-5
Deviation Index	**NA**	**+ 0.1333**	**- 0.3333**	**+ 0.2000**	**- 0.3333**
Percentage Deviation	**NA**	**+ 13.33%**	**- 33.33%**	**+ 20.00 %**	**- 33.33%**

Source: Author's Field work (2014)

The positive deviation index of CU and OAU suggests that they adequately met the NUC-BMAS and a possible strong emphasis on structures. However, FUTA and UNILAG have the same negative deviation index of -0.3333, suggesting a strong similarity in their curriculum by credit units and that they fall short of the NUC-BMAS. The negative deviation index may also suggest a possible mild or fair emphasis on structures in their overall curriculum. Such a fair emphasis on structures may be a response to students' attitudes and perceptions of the course, particularly noting the growing dissatisfaction among architecture students with the structures course as observed by Vassigh (2001). Another possible reason may be the pedagogical philosophies or ideologies of the departments about structures course. Future research work is needed to further examine the possible causes for the observed trends.

(ix) Relative Weight of Structures Credit Units to the Graduation Benchmark

The result of the relative weight of structures course in the architecture curriculum is presented in Table 4.8. The NUC-BMAS has a 6.85% weight, CU has 6.49% and FUTA has 4.23%. OAU and UNILAG have weights of 7.69% and 4.69%, respectively. From the result it can be seen that only OAU (7.69%) superseded the NUC-BMAS weight (6.85%) while CU (6.49%) is slightly lower. It is important to note the similarity in the weights of FUTA (4.23%) and UNILAG (4.69%). This similarity is expected as earlier shown in previous Tables (4.3 and 4.4). However this trend may suggest similarity in fundamental issues of pedagogical ideology, design philosophy, origin of curriculum, age of university, background and training of faculty members.

Table 4.8: Distribution of Relative Weight of Structures Credit Units to the Graduation Benchmark

S/N	INSTITUTIONS	TCUG	TCUS	PERCENTAGE (TCUS /TCUG X 100%)
1.	NUC	219	15	**6.85%**
2.	CU	262	17	**6.49%**
3.	FUTA	236	10	**4.23%**
4.	OAU	226	18	**7.69%**
5.	UNILAG	213	10	**4.69%**

TCUG: Total No. of credit units required for graduation

TCUS: Total No. of credits for structures

Source: Author's Field work (2014)

4.1.4 The Product Dimension of the Structures Curriculum

The product dimension as the last dimension of the Stufflebeam's (CIPP) model comprising context, input, process and product was examined. The learning outcomes were used as the yardstick for evaluating the product dimension of the curriculum. The two possible learning outcomes of structures instructions, namely structural literacy and structural competence were evaluated. Structural literacy is the acquisition of structural knowledge, while structural competence is the ability to use and apply acquired structural knowledge to solve design problems, which is often expressed by structural intuition. Structural intuition is the ability to instinctively use structural knowledge to creatively resolve the structural component of a design problem (Allen, 1997, Black and Duff, 1994).

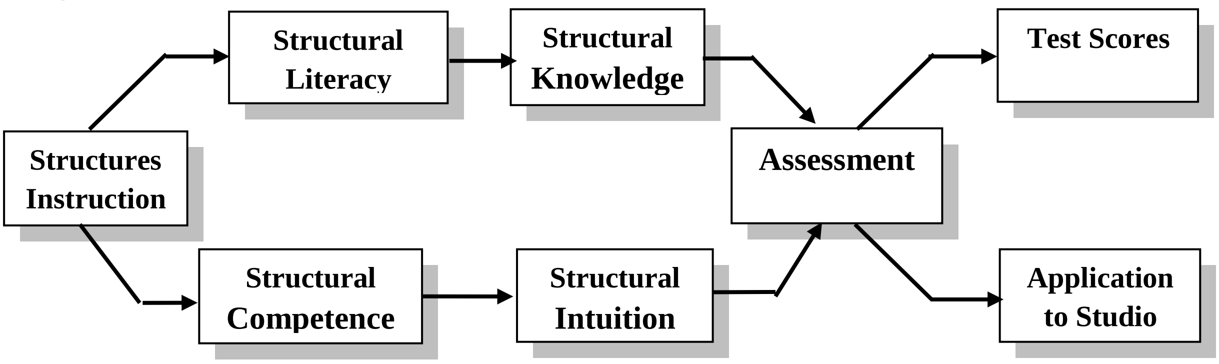

Figure 4.1: Learning outcomes of Structures Instruction
Source: Author's Conception (2014)

While structural knowledge can be effectively assessed and measured by test scores, structural intuition being a higher order skill can be measured by the application of structural knowledge to design studio work of the students. Figure 4.1 shows a graphic illustration of the learning outcomes of structures instruction

(i) Test Scores

The test scores, which is a measure of structural knowledge, were measured using the students' last semester grade on Structures. The findings are presented in Table 4.9 and figure 4.2. Grade A represents 70-100 marks, B represents 60-69 marks, C represents 50-59 marks. D represents 45-49 marks while F represents 0- 44 marks. An examination of the results show that 18.5% of all the students surveyed across the four universities' departments of Architecture had As, 33.1% had Bs and 27.4% had Cs. On the other hand 14.9% of the students had D grade while 6% had E grades.

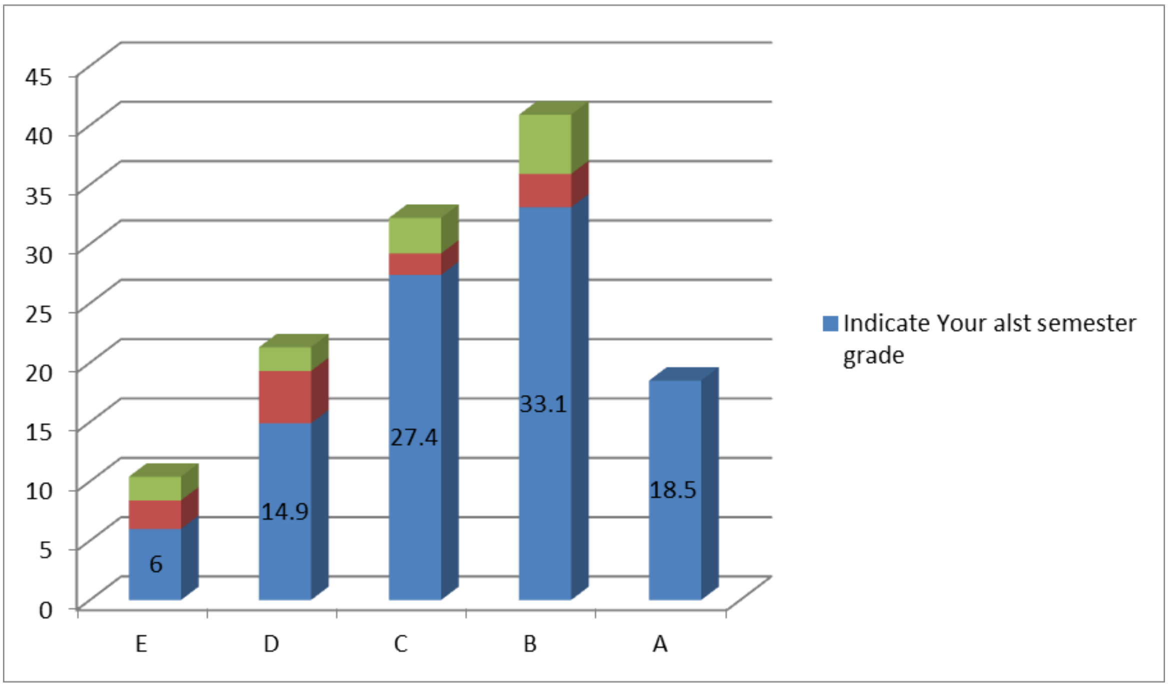

Figure 4.2: Students last semester's grade in structures
Source: Author's Field work (2014)

The result indicates that 79% (18.5+33.1+27.4) of the students scored above 50 marks thus suggesting that a majority of the students achieve acquisition of structural knowledge. Using the sum of the frequencies of grades A-C, a structural knowledge index (SKI) was calculated and as presented in Table 4.9. The value ranges from 0.00 to 1.00. CU has a structural knowledge index of 0.86, FUTA has 0.81, and OAU has 0.77, while UNILAG has 0.64. The result shows that CU has the greatest value of SKI, and thus suggesting that the students in this university achieve greater structural knowledge than those in the other three universities. Next is FUTA with an SKI of 0.81, followed by OAU with an SKI of 0.77. UNILAG has the least SKI of 0.64, while the mean SKI value across the four schools is 0.79. This result shows that the mean SKI is relatively high while the respective SKIs vary from 0.64 to 0.79 with CU having the highest value and UNILAG having the lowest value. It is important to note that the range of the SKI (0.64 – 0.81) is above 0.50 and thus suggesting that all the students in the four departments surveyed achieve a considerably level of structural knowledge.

Table 4.9: Structural Knowledge Index (SKI)

Universities	**Indicate your last semester grade**				**Total**
	C	**B**	**A**	**Frequency A+B+C**	**(SKI) $\frac{A+B+C}{100}$**
CU	17(21.0)	35(43.2)	18(22.2)	**86.4**	**0.86**
FUTA	23(31.5)	24(32.9)	12(16.4)	**80.8**	**0.81**
OAU	16(30.8)	16(30.8)	8(15.4)	**77.0**	**0.77**
UNILAG	12(28.6)	7(16.7)	8(19.0)	**64.0**	**0.64**
Total	**68(27.4)**	**82(33.1)**	**46(18.5)**	**79**	**0.79**

Numbers in bracket represent percentages; Figures outside bracket represent frequencies
Source: Author's Field work (2014)

(ii) Application to Studio

The second component of the learning outcomes of structures instruction evaluated was application of structures knowledge to the design studio projects. This has been described as higher order skills, which include skills that are not easily measured using test scores. Students' responses to the question "*I readily apply the knowledge I gain in my structures classes in my design studio projects"* was used to measure the extent to which the students apply the knowledge acquired in structures classes to their design studio projects. It is evident from figure4.3 that around 25.8% of all the respondents across the four departments claimed that they *always* applied the knowledge acquired in structures class to design studio project, 16.7% agreed to *often* apply the knowledge from structures class to design studio project, while 29.1% agreed to *sometimes* apply the knowledge from structures class to design studio project. On the other hand 17.7% of all respondents agree that they rarely apply the knowledge, and 10.7 % agreed that they never applied the knowledge from structures classes to design studio.

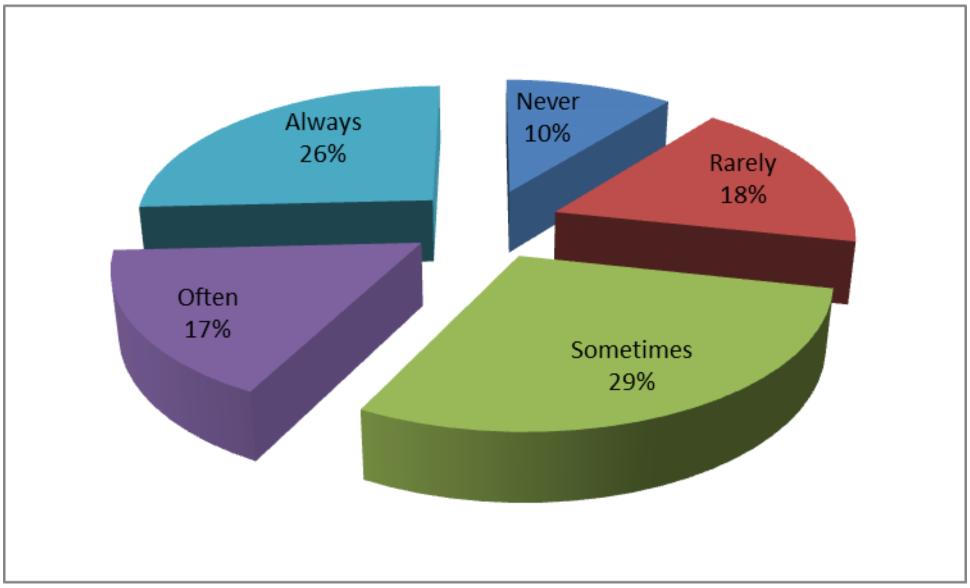

Figure 4.3: Application of knowledge gained in structures classes in design studio
Source: Author's Field work (2014)

The result also indicates that 71.6% (25.8+16.7+29.1) of the students agreed that they "*sometimes", "often" or "always"* apply structures knowledge to studio design project. This suggests that the majority of the students apply structural knowledge to design studio project. In section 4.1.4 of this thesis, the ability to apply structural knowledge to solve design problem has been defined as structural intuition, therefore it can be inferred from the result that 71.6% of the students develop structural intuition. Using the sum of the frequencies of sometimes, often and always, a structural Intuition Index (SII) was calculated and presented in Table 4.10. The value ranges from 0.00 to 1.00. CU has a structural intuition index of 0.776, FUTA has 0.780, and OAU has 0.662, while UNILAG has 0.597. This indicates that the SII across the four universities range from 0.597 to 0.780, which is above 0.500. Hence it can be inferred that the students achieve a considerable level of structural intuition.

Table 4.10: Structural Intuition Index (SII)

Universities	**I readily apply the knowledge I gain in my structures classes in my design studio projects**			**Total**
	Sometimes (3)	**Often (4)**	**Always (5)**	**SII (5+4+3)**
CU	24(25.5)	14(14.9)	35(37.2)	**77.6**
FUTA	24(31.2)	17(22.1)	19(24.7)	**78.0**
OAU	23(32.4)	12(16.9)	12(16.9)	**66.2**
UNILAG	16(28.1)	7(12.3)	11(19.3)	**59.7**
Total	**87(29.1)**	**50(16.7)**	**77(25.8)**	**71.6**

Source: Author's Field work (2014)

A comparison of the structural knowledge index (SKI) and structural intuition index (SII) is presented in Table 4.11. An examination of the ratio of SKI to SII shows that CU has 1.1: 1.0, FUTA (1.0: 1.0), OAU (1.2: 1.0) and UNILAG (1.1: 1.0). This result indicates that the SKI is higher than the SII in each of the four universities. Also the mean SKI (0.790) is higher than the mean SII (0.716). From the result it is evident that there is a significant gap between what is learned and the extent to which they apply what is learnt. It is interesting to observe that this trend is common across all the four universities without any exception. This has serious implications for structures pedagogy. Going by the fact that the structural knowledge index is a measure of structural literacy and structural intuition index is a measure of structural competency, it would appear that the students are more structurally literate than they are structurally competent. This however should not be the case, because the structural competence is the preferred learning outcome of structures instruction. It is therefore imperative that there is a need to bridge this gap by developing appropriate strategies.

Table 4.11: Comparison of Structural Knowledge Index and Structural Intuition Index

Universities	Structural Knowledge Index (SKI)	Structural Intuition Index (SII)
CU	0.860	0.776
FUTA	0.810	0.780
OAU	0.770	0.662
UNILAG	0.640	0.597
Mean	**0.790**	**0.716**

Source: Author's Field work (2014)

4.2 Assessment of Teaching Approaches of Architectural Structures

The aim of this section is to present, interpret and discuss the findings on the approaches to the teaching of structures from the perspective of faculty and students sampled. The section is divided into three main segments. First, is the presentation of results on the teaching approaches and its emphasis. The second presents and discusses the results of the data on the perception of the teaching approaches. Students' perception of the teaching approaches was evaluated from three dimensions namely- structures course, structures classes and structures topics. The section ends with a summary of findings on the teaching approaches, their areas of emphasis and students' perception of these approaches.

4.2.1 Assessment of Teaching approaches and their emphasis

Students and faculty members were sampled to examine the existing approaches to the teaching of architectural structures across the four universities. The data in Table 4.12 is a comparative analysis of the students' and faculty members' responses on the teaching approaches in use.

4.2.2 Lecture Based Instruction

i. Lectures

The Table 4.12 shows that lecture was the most predominant teaching approach with the highest learning outcome index of 4.18 (student) and learning input index of 5.00 (faculty). The high value of 4.59 for the learning yield index indicates a consensus among faculty and students that lecture is indisputably the most predominant teaching approach across the four universities.

ii. Tutorials

The data on tutorials indicates a learning outcome index of 3.41 (student responses), a learning input index of 4.44 (faculty responses) and a learning yield index of 3.94. While all the three indices are above the 3.00 mark indicating that it is a frequently used teaching approach, the negative high value for learning efficiency index of -1.03 is indicative that students receive less tutorials than claimed by faculty. The question here is, what could be responsible for this? Could it be that there is a difference in definition of the term tutorials or otherwise. While this may be further explored in future research, it is noteworthy that tutorials are predominant teaching approach for architectural structures.

Table 4.12: Assessment of Teaching approaches

S/N	Teaching Approaches	Faculty (A) Learning Input Index (LII)	Student (B) Learning Outcome Index (LOI)	(A+B)/2 Learning Yield Index (LYI)	Variance (B-A) Learning Efficiency Index (LEI)
A	**Lecture Based Instruction**	***4.72***	***3.80***	***4.27***	***-0.92***
i.	Lectures	5.00	4.18	4.59	-0.82
ii.	Tutorials	4.44	3.41	3.94	-1.03
B.	**Project Based Instruction**	***2.42***	***2.78***	***2.60***	***+0.36***
i.	Group Based Projects	2.40	3.38	2.89	+0.98
ii.	Laboratory tests & investigations	2.43	2.17	2.30	-0.26
C.	**Case Based Instruction**	***3.55***	***2.89***	***3.22***	***-0.66***
i.	Study of structural failures	3.57	2.81	3.19	-0.76
ii.	Study of historical structures	3.83	2.99	3.41	-0.84
iii.	Case studies from practice	3.25	2.88	3.07	-0.37
D.	**Visual Based Instruction**	***3.15***	***2.91***	***3.03***	***-0.24***
i.	Usage of Graphics- (Sketches & Pictures)	4.13	3.11	3.62	-1.02
ii.	Use of models (Physical, 3D-Computer generated models)	2.17	2.71	2.44	+0.54

Source: Author's Field work (2014)

4.2.3 Project Based Instruction

i. Group Based Projects

The findings on group-based project indicate a low learning yield index of 2.89, implying that it is not a predominantly used teaching approach in the universities surveyed. The learning outcome index (students response) was found to be 3.38, a low learning input index of 2.40. While the learning efficiency index (variance) of +0.98 is relatively significant, it is clear that they are both close to the 3.00 mark indicating fair usage. It is important to note that the learning outcome index (students' response) of 3.38 as compared to the learning input index (faculty response) of 2.40 indicates that though the teaching mode is not inclined towards group- based projects, the students tend to be more inclined towards this teaching and learning approach. This result only goes to validate the fact that architectural education is inclined towards group based project, which is an indicator of the diverger and accommodator learning styles that have been associated with architecture students (Tucker, 2007; Singhasiri, Darasawang and Srimavin , 2004).

ii. Laboratory tests & investigations

The findings on laboratory tests and investigations show that with learning input index of 2.43, learning output index of 2.17 laboratory tests and investigations are rarely used teaching approach in architectural structures across the four universities surveyed. While the data on this teaching approach indicates that this approach is rarely used, it is important to note that this approach provides effective learning opportunities for concrete learners, which a majority of architecture students are characterized.

4.2.4 Case Based Instruction

i. Study of Structural Failures

The data on study of structural failures shows a learning outcome index of 2.81(students). This indicates that it is not a predominant teaching approach from the students' perspective. It was observed that the learning input index (faculty response) is 3.57, indicating that it is a fairly predominant teaching approach from the faculty members' perspective. The learning yield of 3.19 indicates that it is a fairly predominant teaching approach. The learning efficiency index (variance) at a marginal difference of -0.76 is indicative of a communication gap between what is being taught and what is being learnt. From the learning outcome index of 2.81 it can be inferred that study of historical structures is not a predominant teaching approach in the four universities surveyed.

ii. Study of Historical Structures

The findings on the study of historical structures show a learning input index of 3.83, learning outcome index of 2.99 and a learning yield index of 3.41. The 2.99 value for the learning outcome index indicates that the study of historical structures is neither a predominant nor dormant teaching approach. It could be said to be a fairly used approach. However, a study by McNamara, (2011) revealed that the study of historical structures facilitate students' understanding of fundamental structural principles and promotes a greater appreciation of the design potential associated with structural optimization. That study also noted that the most encouraging results from the survey were the ones that the students felt that the study of historical precedent had value both in learning the new concepts and in appreciating how those concepts were useful and relevant in their own work. McNamara (2011) also observed that 90% of the survey respondents either agreed or strongly agreed that historical case studies made it easier to understand the course material and promoted a deeper appreciation of the role of structural engineering in architecture. Based on this, he concluded that historical precedent is valuable in student engagement both in structures and the application to their design studio. Hong (2011) noted that studying historic and modern buildings, which have distinctive structural elements as architectural expressions strongly, connects students to the technological side of architecture.

iii. Case studies from practice

The result on case studies from practice shows that learning input index is 3.25, learning output index is 2.88, while the learning yield index is 3.07. The marginal proximity of the three indices above to the 3.00 mark is indicative that case studies from practice are a fairly used teaching approach in architectural structures. While there is little empirical research on case based instruction in structures, suffices it to say that the deductions on the use of study of historical structures as teaching approach would subsist. In this case, the current practice where case studies from practice are fairly used denies the students the opportunity to connect to the technological side of architecture.

4.2.5 Visual Based Instruction

i. Usage of Graphics- (Sketches & Pictures)

The learning input index for usage of graphics was observed to be a high value of 4.13, which contrasted significantly with the learning output index of 3.11 and the learning yield index of 3.62. The 3.11 value of the learning output index is indicative that though, the use of graphics is neither a predominant nor a dormant teaching approach, it is a fairly used teaching approach. The relatively high value of the learning efficiency index of -1.02 is indicative of a gap in communication, where learning input by faculty is not translating to the desirable learning outcome in the students. Bridging this communication gap becomes critical if a deeper understanding of architectural structures is desired. Whereas the findings of the study have shown that the use of graphics is not a predominant teaching approach in the teaching of structures, studies have indicated the potential of visual communication of structural concepts. Hong (2011) observed that visual communication, other than esoteric equations could be a friendly solution in stimulating the interest of architecture students. He reported that course evaluations and surveys over a 3- year period revealed that students strongly supported this teaching methodology. He posited that this teaching mode results in and emphasizes visual thinking over mathematical thinking. In fact, visual thinking is a key learning outcome of architectural education. It can be inferred from the submission that a fundamental goal of architectural education is missing in the teaching of structures in the schools surveyed.

ii. Use of models (Physical, 3-dimensional – Computer generated models)

The finding on the use of models with a learning input index of 2.17 and learning output index of 2.71 indicates that it is not a predominant teaching approach in architectural structures in the four universities surveyed. The learning efficiency index of +0.54 is indicative of the fact that though the teaching mode is rarely used, architecture students are inclined to it. This inclination towards the use of models, a concrete learning aid can be seen as a manifestation of their dominant learning style of diverging and accommodating, which is characterized by the use of concrete and realistic models as against theoretical and abstract models. While this teaching approach is scarcely used in the teaching of structures as observed in this study, recent studies show that it is an effective medium for communicating structural concepts. In his work Sweetening Structural Principles for architectural students, Hong (2011) observed that small- scale modeling provides students with opportunities to find that learning structures could be a more enjoyable experience that leaves a stronger impression for longer retention. He observed that visualizing and experiencing 3-dimensional (3-D) structural behaviours help students realize the deviation between textbook solutions and real-world physical phenomena. Hence, the use of 3-D model should be an integral part of structural instructions.

4.2.6 Students' Perception of Architectural Structures

It was of interest to the researcher to examine students' perception of architectural structures as a course. The assessment considered students perception of architectural structures as a course of study, its classes and the existing teaching approaches in the four departments of architecture surveyed. Perception has been described as the way in which something is regarded, understood, or interpreted. Michener *et al.,* (2004) refers to perception as constructing an understanding of the social world from the data we get through our senses. It can be inferred that perception refers to the process by which we form impressions of other people's traits and personalities. Rao and Narayan (1998) described perception as the process of people selecting, organizing, and interpreting sensory stimulations into meaningful information about their (work) environment. A key argument of their proposition is that perception is the single most important determinant of human behaviour. This forms the significance for the study on the perception of architecture students towards structures.

In this study, students were asked to rate several aspects of structures classes guided by value statements using a five-point scale ranging from strongly disagree to strongly agree. A ranking of responses to the value statements of the different aspects of structures was carried out. Presented in Table 4.13 are the results of students' responses to standardized questions on structures as a course. "Structures places emphasis on calculations/analysis" ranked first with a mean score of 3.98. Ranked next was "Structures is relevant to my studies" with a mean score of 3.95 followed by "Structures is relevant to my design studio work" which ranked third with a mean score of 3.90. "Structures is interesting to me" ranked fourth with a mean score of 3.44, followed by "Structures is practical and easily applicable" which ranked fifth with a mean score of 3.27 and "Structures is abstract/ Theoretical" which ranked sixth and last with a mean score of 3.26.

Table 4.13 Ranking of Students Perception of Structures as a Course

Structures as a Course	**Mean Score**	**Rank**	**Sub-Component**
Places emphasis on calculations/Analyses	3.98	1	Emphasis
Is relevant to my studies	3.95	2	Relevance (Architecture)
Is necessary in my design studio work	3.90	3	Relevance (Design)
Is interesting to me	3.44	4	Interest
Is practical and easily applicable	3.27	5	Application
Is abstract/Theoretical	3.26	6	Approach/Ideology

Source: Author's Field work (2014)

The result (Table 4.13) shows that a majority of the students sampled seemed to agree that architectural structures places emphasis on calculations and analyses. The question that may arise from this finding is that, what is the implication(s) of a *calculation and analyses biased* course in architectural education? The immediate response can be found in the learning styles of architecture students. Earlier results from this study on the learning styles of architecture students indicated that a majority of them are divergers and accommodators as contrasted to convergers and assimilators. A key attribute of assimilators and convergers is the ability to explore analytical models, which is unlike divergers, and accommodators who prefer practical or concrete models. From the foregoing it can be inferred that the learning styles of architecture students who are mainly divergers and accommodators characterized by preference for practical or analytical models is at variance with the calculation and analytical emphasis of the architectural structures course.

Regarding the secondary response to the calculations and analyses biased structures course, it is important to have a quick look at the communication medium of architects. Architects are trained to develop visual communication skills, which are reflected in their abilities to solve human problems with appropriate design thinking and usually communicated visually with the aid of drawings and models. It may thus be inferred that the communication skills of the architecture students is at variance to the emphasis of structures, which according to this study is mathematically intensive with calculations and analyses. Structural engineers use formulae and equations to define and clarify the engineering concepts, while architects use drawings and models for communication. Dytoc (2007) argued that architects use graphics and models for communication, and not the symbol-laden vocabulary of mathematical formulae and has thus, evolved an approach that uses graphics effectively. This position corroborates the assertion by Hong (2011) that to stir the architectural students out of the inactive mode in structures courses, the gap between the two professionals, architects and structural engineers must be correctly addressed and understood. He further noted that the gap between artistically creative fickleness and rigidly compliant performance must be bridged by carefully devised training.

The relevance of structures to the students was assessed using two parameters, namely "Structures is relevant to my studies" and "Structures is necessary to my design studio work."

The mean scores for the two variables are 3.95 and 3.90, respectively. The implication of the result is that a majority of the students perceived Architectural Structures to be relevant to their studies and their design studio. Despite the fact that a majority of the students acknowledged that structures is relevant to their studies, their level of interest appears to be fair or relatively low as it ranked fourth with a mean score of 3.44. That both Structures is practical and easily applicable; and Structures is Abstract and Theoretical with a mean score of 3.27 and 3.26, respectively ranking fifth and sixth, which is relatively low suggests a measure of indecisiveness on the subject matter.

The implication of an abstract and theoretical-based course in architectural education can also be benchmarked with some key parameters. One key parameter here is the learning style profiles of the students. With respect to the findings of this study, architecture students are predominantly divergers and accommodators, who are characterized by a preference for concrete models, imaginative ability, as contrasted to the convergers and assimilators who have strong ability in practical application of ideas and to create theoretical models. Thus, it can be inferred that the learning styles of architecture students are at variance to their perception of structures. To ensure optimum learning such a fundamental issue as this must be addressed by making teaching the course using a practical approach.

4.2.7 Students' Perception of Architectural Structures Classes

Table 4.14 presents the ranking of the responses of the students to the different aspects of structures in their respective departments. "I undertake life projects for the purpose of structures" ranked first with a mean score of 3.51. This is followed by "I understand how to do the calculations", which ranked second with a mean score of 3.46. "I enjoy the calculations and analyses aspects of structures" which ranked third with a mean score of 3.35, while “I like the organization of the topics and the teaching approaches contributes to a better understanding” ranked fourth and fifth with mean scores of 3.29 and 3.26, respectively. Also "The times for the lectures are very conducive to me, “I enjoy the theoretical aspects of structures course” and “I enjoy structures lectures” ranked sixth, seventh and eight with mean scores of 3.22, 3.21 and 3.19, respectively.

Table 4.14 Students’ perception of structures classes

Structures Classes/Course Content	**Mean Score**	**Rank**
I undertake life project(s) for the purpose of structures	3.51	1
I understand how to do the calculations	3.46	2
I enjoy the calculations & analysis aspects of structures	3.35	3
I like the organization of the different topics taught in structures	3.29	4
The approach (es) to teaching structures contributes to a better understanding of the course	3.26	5
The times for the lecturers are very conducive to me	3.22	6
I enjoy the theoretical aspects of structures course	3.21	7
I enjoy structures lectures	3.19	8
Assessment methods bring out the best in me	3.15	9
The organization of the lectures helps me to develop interest and understand the course	3.14	10
I participate actively in structures classes	3.13	11
The format for delivery of the course contents helps me to understand the course better	3.09	12
I attend field trips for the purpose of structures	2.51	13
I readily apply the knowledge I gain in my structures classes in my design studio projects	2.36	14

Source: Author’s Field work (2014)

These were followed by “Assessment methods bring out the best in me” and “organization of the lectures helps me to develop interest” and “understand the course” with mean scores of 3.15 and 3.14, respectively. “I participate actively in structures classes” and “the format for delivery of the course contents helps me to understand the course better” ranked eleventh and twelfth with mean scores of 3.13 and 3.09, respectively. The least ranked are “I attend field trips for the purpose of structures classes” with a mean score of 2.51 and “I readily apply the knowledge I gain in my structures classes in my design studio projects” with a mean score of 2.36.

The ranking shows that a majority of the students are well disposed to the value statements measured because twelve of the fourteen statements have mean scores higher than 3.00, while the other two value statements have mean scores lower than 3.00. An examination of the least ranked value statement: “I readily apply the knowledge I gain in my structures classes in my design studio projects” with a mean score of 2.36 indicates that a majority of the students do not readily apply the knowledge gain in structures classes in their design studio projects. This result indicates that the popular notion of dichotomy between architecture and structure, which was aptly captured in the assertion by Black and Duff (1994) that graduating students have no meaningful understanding of structural behaviour, have little practical knowledge to apply as professionals, and are thus forced to concede all but elementary structural matters to engineers. This seems to provide support to the assertion that though the students are well disposed to the teaching approaches and classes, they do not readily apply what they learn in structures class to design studio, which in itself is the goal of teaching structures. It may thus be inferred that there is a low degree of relatedness of the structures curriculum to the design studio. The result also suggests the possible notion of relevance of the structures curriculum to design studio. Noting that the architect is to use structure as a major design determinant, the above result on the significantly low level of application and use of structure in the design studio suggests a need for a rethink of the curriculum of structures.

That majority of the students do not apply the knowledge gained in structures to their design studio work can also be measured against the background of the concept of curriculum evaluation described by Glatthorn, *et al.* (2012) as: *The assessment of the merit and worth of a program of studies, a field of study, or a course of study*. Merit is established without reference to a context, while **Worth**, is the value of an entity with reference to a particular context or a specific application. It is the "payoff" value for a given institution or group of people. It is therefore obvious that structures as a course weighs high on the merit scale but very low on the worth scale. It could therefore be inferred that the current structures course in the four universities surveyed has merit however has little or no worth to the students. This conclusion is very significant because a course that takes approximately 6% of the curriculum has little worth yet the importance of structures as the support system of a building cannot be under estimated, for without structures architecture cannot stand. It is in the light of this that a need to rethink the curriculum of structures and develop strategies to improve students' interest and understanding have become imperative.

4.2.8 Perceived difficulty of Structures Topics

Students perception of the degree of difficulty of structures topics was also assessed and the result presented in Table 4.15 "*Analysis of statically determinate and Indeterminate structures"* ranked no. 1 with the highest mean score of 3.03, "*Design of Structural members (reinforced concrete beams/ steel beams/columns/slab)"* and "*Theory of Structures"* ranked no. 2 with a mean score of 2.88 each. *Statics (Equilibrium, Support reactions)* and *Dynamics (Forces)* ranked 3 and 4 with mean scores of 2.78 and 2.76, respectively.

Table 4.15 Perceived difficulties of structures topics (students only)

Topics	**Year of Study**	**Mean Score**	**Rank**
Analysis of Statically determinate & Indeterminate structures	4	3.03	1
Design of Structural members (reinforced concrete beams/ steel beams/columns/slab)	3, 4	2.88	2
Theory of Structures	2, 3	2.88	2
Statics (Equilibrium,Support reactions)	2	2.78	3
Dynamics (Forces)	2	2.76	4

Source: Author's Field work (2014)

An examination of the result in Table 4.15 shows an inverse relationship between the year of study and the degree of difficulty. It can be deduced from the result that the students perceived the topics/ subject areas to be increasingly difficult as they progress in their studies. While this may not be unexpected in any field of study, noting the progressive dissemination of knowledge, it is important to state that the topics that ranked higher on the difficulty scale have greater relationship to architectural design. This high degree of difficulty of structures may help to explain why the students do not apply what they learn in structures class to their studio projects. Thus, the need to devise strategies that can improve students' understanding of the course.

4.2.9 Willingness to Choose Structures if made Optional (as an elective)

In an attempt to measure the overall perception of students about structures, the students were aked "*If Structures is optional, would you choose it?".* The result of responses to this question is presented in Figure 4.4. It is evident from the result that 56.9% of the students would choose to take the course, while 42.8% will not. The relatively high proportion of those that indicated "No" reveals the low level of interest in structures and yet structures is a very important part of the curriculum as it is expected to provide relevant knowledge and skill on the support systems of buildings, without which buildings cannot stand and therefore architecture cannot exist.

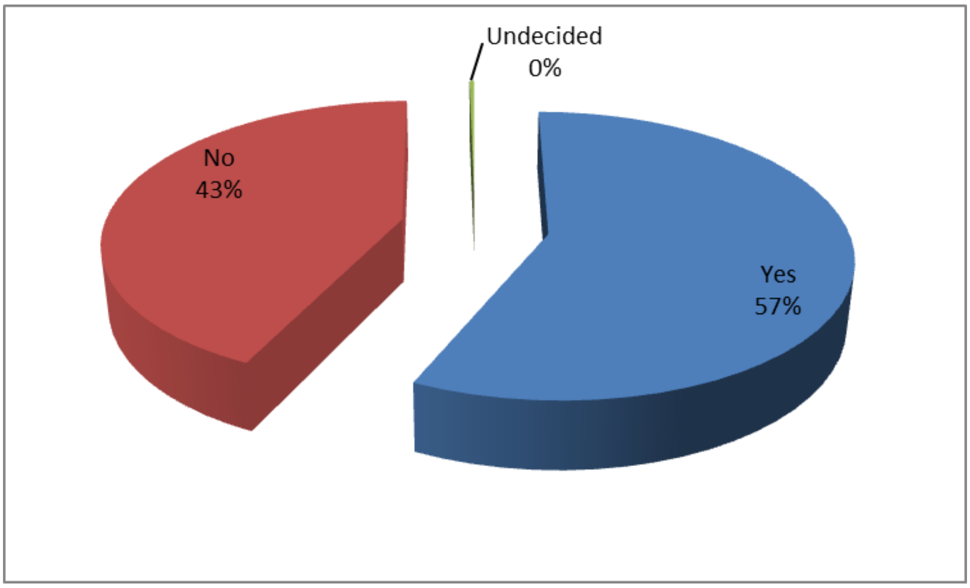

Figure 4.4 If Structures is optional, would you choose it?
Source: Author's Field work (2014)

The findings on the students' perception of architectural structures as a course show that majority of the students perceived architectural structures as a course placing emphasis on calculations/analyses, and that it is relevant to their study of architecture and the design studio. However, they did not find structures to be as interesting, practical and easily applicable course. In fact, the study shows that a majority of the students claimed that they do not apply what they learnt in structures classes to their design studio work, thus suggesting a disconnect between what is taught in structures and the design studio work. This development obviously presents a need to rethink the pedagogy of structures in terms of curriculum and instructional strategies.

Evidence from the study also shows that the subject areas were perceived to be increasingly difficult as the students progressed to higher academic levels. The result of the analysis further showed that 43% of the students would rather not choose structures if made optional, while 57% would choose it. Though a majority 57% would choose it, the relatively high proportion (43%) of the students that would not choose structures could be indicative of the relatively low interest level in structures by the students. Hence there is a need to devise strategies to improve level of interest of architecture students' in structures.

4.3 Students' Personality Profile

The study examined the students' personality profiles in the four departments of Architecture surveyed. The demographics, the personality characteristics and the learning styles were examined. The study further examined the relationship between the personality profile and the curriculum. The relationship between learning styles and the curriculum was also examined. The findings are presented in this section of the thesis.

4.3.1 Demographics

(i) The Respondents across the Four Universities

The total of 309 students across the four levels (200, 300, 400 and M.Sc1) where structures course is taught across the four universities were sampled. The distribution of the students who participated in the research across the four universities shows that 30.4% were from Covenant University (CU), 26.8% from the Federal University of Technology Akure (FUTA), 23.9% from Obafemi Awolowo University (OAU), while 18.8% were from the University of Lagos (UNILAG) as shown in Figures 5.5. The lower figure reported for UNILAG was as result of the fact that the 300 level students were on Industrial Training as at the period of data gathering (i.e October-November, 2014). The result indicates that around 28.5% of the respondents were in 200 level, 21% in 300 level, 25.9% in 400 level while

24.6% were in M.Sc. 1 classes. This suggests a variance in the academic structure of the architecture programme in the four universities. Such a variance may also suggest variance in the depth of coverage of the curriculum for structures. The distribution of the respondents across the four levels and the four universities was intended to provide a balanced opinion from students.

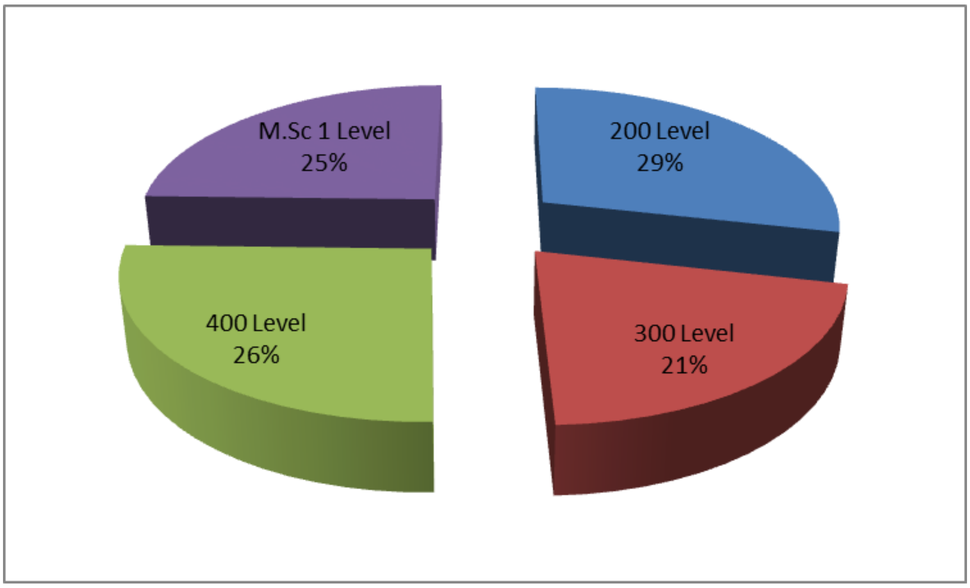

Figure 5.5: Level of Study of Respondents
Source: Author's Field work (2014)

(ii) Gender of The Respondents

The result in Figure 5.5 shown indicates that around 64.8% of the respondents across the four universities were males, while 35.2% are females. Data from CU (shows 58.5% males and 41.5 females) and UNILAG (shows 57.9% males and 42.1% females) indicates a closer and fairer margin while FUTA (73.5% males and 26.5% females) and OAU (68.5% males, 31.5% females) showed a wider margin. The wider margin could be linked to the fact that the FUTA being a university of technology confirms the gender bias that Science and Technology is male dominated. Fundamentally, the general results of 64.8% for males and 35.2% for females confirms the position in literature that architecture is a male dominated profession.

This finding support the results of a previous study by Aderounmu (2013), on design studio conducted across three of the four universities (CU, LAUTECH, OAU and UNILAG) where he reported a ratio of 2: 1 for males and females, respectively. The result also appears to be in tandem with the prevailing global position that architectural practice and education is gender imbalanced (see De Graft-Johnson, Manly, and Greed, 2003, Oluwatayo, 2009,).

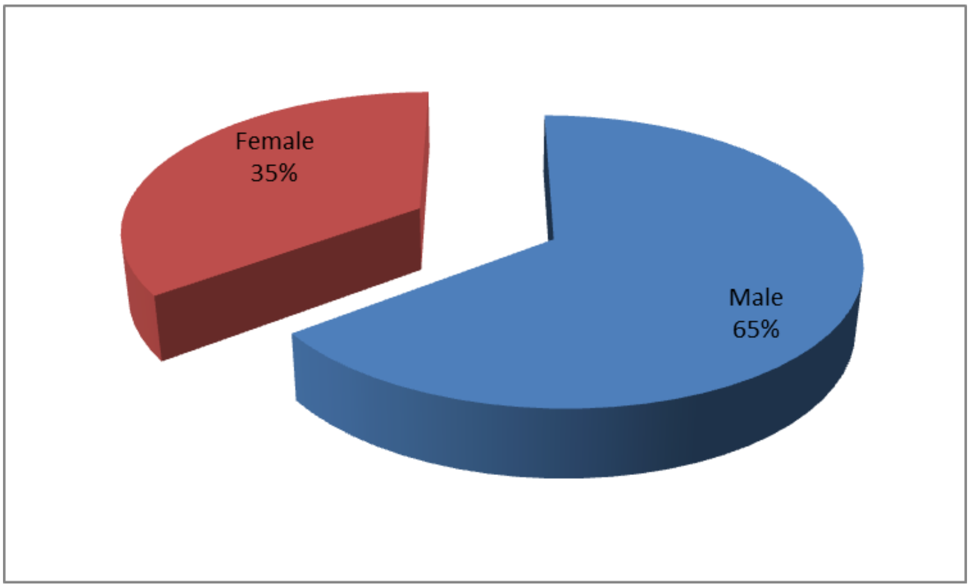

Figure 5.6: Gender of The Students
Source: Author's Field work (2014)

(iii) Age Groupings of The Students

Figure 4.7 shows the distribution of the sampled students according to their age groupings. The result reveals that the majority (63.0%) of the students were between 19years and 22 years, while the minority (5.2%) were above 27years. The other categories are those between 15years and 18 years which accounted for 12.8%, and those between 23years and 26 years that constituted around 19% of the respondents. This result is not unexpected because persons in these age grouping are predominantly students. However, an interesting result was found in CU that has the highest proportion (29.8%) of the least age grouping (15-18 years) as compared to FUTA-2.4%, OAU-8.5% and UNILAG-5.3%. It may thus be inferred that CU, a private university, attracts younger students than the public universities. This result corroborates the findings of Aderounmu (2013), with CU-90%, LAUTECH-83% and UNILAG-74%, for students within the age bracket of 16-25 years.

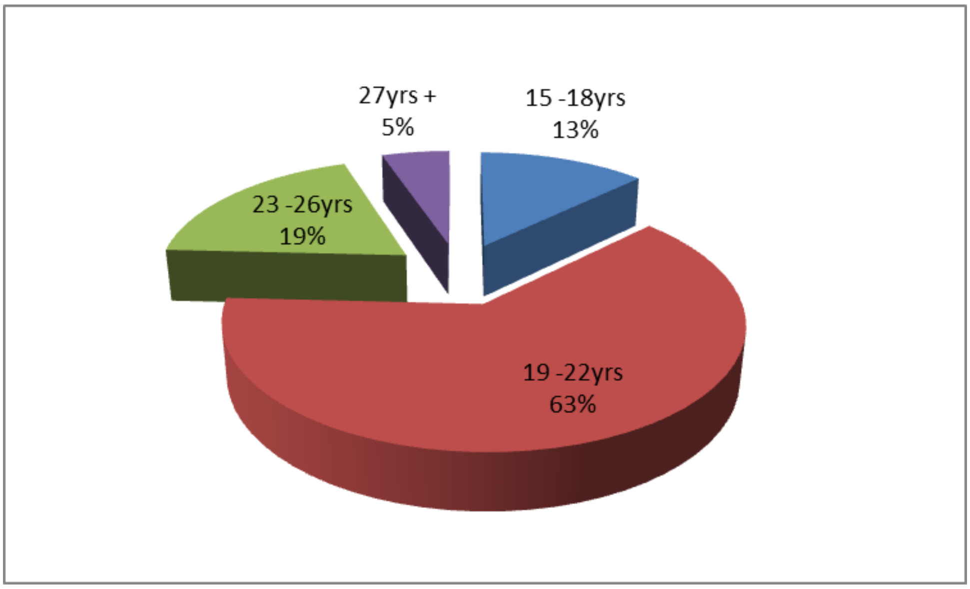

Figure 4.7: Age Grouping of The Students
Source: Author's Field work (2014)

(iv) Academic Performance of Students (By Cumulative Grade Point Average-CPGA)

Academic performance of the students was examined using the students' CGPA. It was observed as reported in Figure 4.8 that a majority (54.2%) of the students were in the 3.50-4.49 (i.e Second Class Upper division), followed by the 2.50-3.49 (Second Class lower division) with a proportion of 33.2%. The other categories surveyed were the 1.50-2.49 (Third Class division) accounting for 2.6% while the 4.50-5.00 (First Class division). This result indicates a good academic performance across the four universities. Also, the results show a unique trait in UNILAG with the least proportion (0%) of students in the third class category, followed by CU with 2.2%. Noteworthy is the fact that the highest proportion of students in the First Class categories were also found in UNILAG (14.6%) followed by CU (13.3%). The result from UNILAG also indicates that 70.8% of the students are in the second class upper division with CU having a similar result of 64.4%. It can thus be inferred that the students in these two universities have high academic performance than those in FUTA and OAU. It also suggests that UNILAG and CU have a robust academic environment capable of producing high performing students or that they attract and recruit talented students.

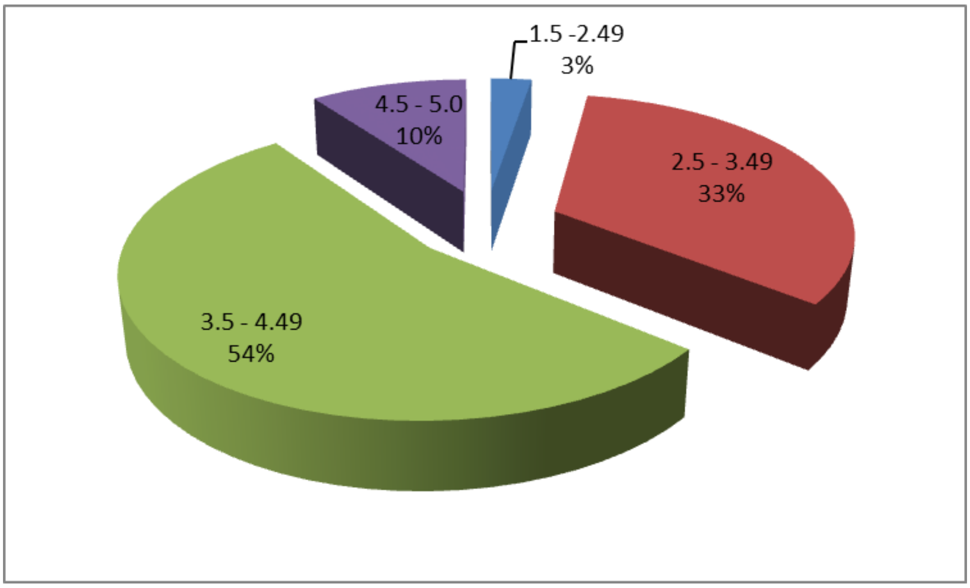

Figure 4.8: Academic Performance of Students (Cumulative Grade Point Average-CPGA)
Source: Author's Field work (2014)

4.3.2 Personality Profile (PP)

The personal profiles of architecture students across the four universities were sampled using the Myers – Briggs Type Indicator (MBTI). The MBTI evolved from the theory advanced by C.G. Jung and put into operation by I.B. Myers and K.C. Briggs. At present, the MBTI is one of the most widely utilized instruments for effectively measuring personality differences. It has been used for many other different purposes including self- development, career development, relationship counseling, academic counseling, organizational development, management and leadership training, education and curriculum development (Brien *et al.*, 1998). The MBTI measures four separate preferences or 'indices' concerning perception and judgement. The preferences have implications for not only what people attend to in any given situation, but also how they draw conclusion about what they perceive. The four separate preferences measured include:

1. Orientation to life: Extroversion (E) versus Introversion (I)
2. Perception: Sensing (S) versus Intuitive (N)
3. Decision-Making: Thinking versus Feeling
4. Attitude to life: Perceptive (P) versus Judgement (J)

For the purpose of this study, architecture students personal profile were examined using two of the four dimensions, namely: Orientation to life (Extroversion vs Introversion) and Perception: Sensing (S) versus Intuitive (N). These two have been chosen for their appropriateness to design studio and architectural structures.

(i) Orientation to Life Dimension: Extroversion vs Introversion

Table 4.16 shows the result of the mean scores and total scores across five parameters used in evaluating the orientation to life of architecture students in the four universities surveyed. The result indicates that the mean scores ranged from 2.01 to 3.78. The parameter *"I like acting first, and then* ***think/reflect*** *later"* had the lowest mean score, which implies that only a minority of the students exhibit this characteristic. So it can be concluded that a majority of the students sampled think/reflect before acting. The parameter "*I am usually open to and* ***motivated*** *by the outside world, people and things"* had the highest mean score of 3.78, which implies that a majority of the respondents are motivated by the outside world, people and things.

Generally, four of the five variables used in accessing orientation to life had mean scores above 3.00 (3.28, 3.78, 3.38 and 3.17) and total average mean score of 3.12. This result implies that most of the respondents are extroverts. This finding has implications for learning and teaching, which will be considered, in the next section of the thesis.

Table 4.16 : Orientation to Life Dimension (Extroversion vs Intoversion) : Personality Charactersitics

S/N	Personal characteristics of Architecture students	Total Score	Mean Score
1.	I like acting first, and then **think/reflect** later	618	2.01
2.	I feel deprived when cut off from **interacting** with the outside world	1007	3.28
3.	I am usually open to and **motivated** by the outside world, people and things	1161	3.78
4.	I enjoy wide **varieties** and changing **relationships** with people	1040	3.38
5.	I prefer outer world activities, excitements, people, & things to **1-on-1 communication**	969	3.17

Source: Author's Fieldwork (2014)

Table 4.17 : Orientation to Life (Extroversion vs Introversion) – Personality Profile

S/N	Personality Type	Average Total Score	Average Mean Score	Frequency
1.	Extroversion	959	3.12	193(62.4)
2.	Introversion	586	1.88	116(37.6)

Numbers in bracket represent percentages; Figures outside bracket represent frequencies
Total weighted score: 1545 Maximum Score: 5
Source: Author's Fieldwork (2014)

(iii) Perception Dimension: Sensing (S) versus Intuitive (N)

This parameter was measured on a 5 point Likert scale, with 3 as the midpoint. Using 3 as the mid-point and mean score, scores less than 3.00 (1.00- 2.99) indicates negative position of the parameter while scores greater than 3 indicates positive position. For the perception dimension of the personality type using the MBTI, mean scores from 1.00-2.99 means that the respondents are characterised by the intuition (N) personality type i.e. they are *intuitors,* while the mean scores from 3.00-5.00 is characterised by the sensing (S) personality type i.e. they are *sensers.* Table 4.18 shows the result of the mean scores and total scores across seven parameters used in evaluating the perception of architecture students in the four universities surveyed. The results indicate that the mean scores ranged from 3.33 - 3.89. The parameter *"I am mentally alive in the now & attending to **present opportunities** than **future ones"*** had the lowest mean score of 3.33, which is relatively high, while the parameter *"I like **categorizing, organizing, recording** and **storing** the specifics from here & now"* had the highest mean score of 3.89. So it can be concluded that a majority of the students surveyed are of the sensing personality type that is they are sensers.

Table 4.18: Perception Dimension (Sensing versus Intuitive): Personality Characteristics

S/N	Personal characteristics of Architecture students	Total Score	Mean Score
1.	I am mentally alive in the now & attending to **present opportunities** than **future ones**	1002	3.33
2.	I like using **common** sense and creating practical solutions rather than **imagining** future possibilities	1041	3.41
3.	My memory recall is rich in detailed facts and past events than **ordinary patterns**	1011	3.61
4.	I like **improvising** from past **experience** rather than **theoretical** applications	1108	3.67
5.	I like clear and **concrete information;** dislike **guessing** when facts are "fuzzy''	1172	3.86
6.	I like **categorizing, organizing, recording** and **storing** the specifics from here & now	1167	3.89
7.	I prefer **reality** based work, dealing with **specific** meaning of things than **imaginations**	1130	3.70

Source: Author's Fieldwork (2014)

All of the seven variables used in measuring perception dimension of the personality type of architecture students in the four universities had mean scores above 3.00 (Table 4.18) and total average mean score of 3.12. This result implies that 72.8% (225 students) of the 309 respondents are sensers while 27.2% (84 students) are intuitors (Table 4.19). This finding has significant implications for learning and teaching, which will be considered, in the next section.

Table 4.19: Distribution of the Perception Dimension: Personality Profile

S/N	Personality Type	Average Total Score	Average Mean Score	Frequency
1.	Sensing	1090	3.64	225(72.8)
2.	Intuition	455	1.36	84(27.2)

Numbers in bracket represent percentages; Figures outside bracket represent frequencies
Source: Author's Fieldwork (2014)

4.3.3 Learning Styles of The Students

There are different ways in which students learn (Serasin, 1999). Some take hold of information best by listening, while others learn better through reading, reasoning, or discovering concepts through (a hands-on) experience. These different ways of learning, which suggest the distinctive and preferred way a learner organizes and retains information, are referred to as learning style (Potangaroa and Murphy, 2004). The significance of learning style models lies in the fact that by understanding how students think and learn, rather than operating on assumptions, more responsive and customized modes of teaching can be deployed to optimize learning outcomes. Fletcher, Potts, and Ballinger (2008) further noted that "an understanding of the preferred learning style of an individual provides an insight into the teaching methods that are likely to be most effective for that individual". This study adopted a modified Kolb Learning Style Inventory and modified students' responses questionnaires. There was a five- point Likert-type scale ranging from 1 = strongly disagree to 5 = strongly agree. The result is presented in Table 4.20:

Table 4.20 Distribution of Kolb Learning Styles

Learning Styles	**Mean Score**	**Frequency (Percentage)**
Diverger	3.56	110 (35.59)
Assimilator	1.48	46 (14.76)
Converger	1.44	44 (14.41)
Accommodator	3.52	109 (35.24)
Total		**309 (100)**

Source: Author's Field work (2014)

The result in Table 4.20 show the distribution of the learning styles of the students surveyed. Across the four universities, 309 students were surveyed. Students with the diverging learning style (divergers) constituted around 35.9% (110 students) of the sample while students with the assimilating learning style make up 14.76% (46 students) of the sampled population. Students with the converging learning style (convergers) constituted around 14.41% (44 students) and students with accommodating learning style (accommodators) produced 35.24% (109 students) of the sample. The findings show that a majority of the architecture students sampled are divergers (35.59%) and accommodators (35.24%), while the minority is convergers (14.41%) and assimilators (14.76%).

4.3.4 Profiles of Faculty

Having examined the teaching approaches, students perception of the teaching approaches, the students personality profile, examining the profiles of the faculty became imperative so as to adequately situate the study and provide a balanced position on the components of this study. The study therefore investigated demographics, educational background and experience of faculty teaching architectural structures across the four universities.

4.3.5 Respondents across the four Universities

The data in Table 4.21 shows that there are a total number of 10 lecturers teaching structures in the four universities surveyed. CU has a total number of 4 lecturers (40%), FUTA has 2 lecturers (20%), OAU has 2 lecturers (20%) and UNILAG has 2 lecturers (20%). The number of faculty members' teaching architectural structures is the same across three of the four universities except for CU, where there are four lecturers. The two faculty teaching structures in each university might have been a result of the fact that the course is taught at four different levels (200, 300, 400 and the M.Sc. level), with a lecturer taking two different levels. While this appears to be sufficient, the situation in CU with 4 lecturers taking the course across the four levels suggests possible greater attention and input given to the teaching of structures. The smaller student-faculty ratio may also contribute to improved learning outcome.

Table 4.21: Respondents across the four Universities

Universities	**Sex**		**Total**
	Male	**Female**	
CU	3	1	**4(40)**
FUTA	2	0	**2(20)**
OAU	2	0	**2(20)**
UNILAG	2	0	**2(20)**
Total	**9(90)**	**1(10)**	**10(100)**

Numbers in bracket represent percentages; Figures outside bracket represent frequencies

Source: Author's Field work (2014)

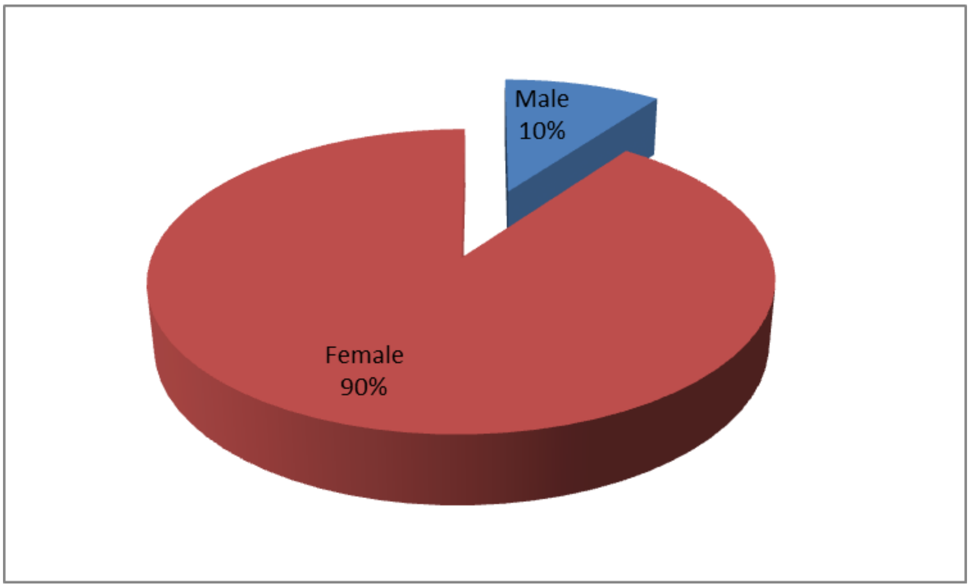

Figure 4.9: Respondents across the four Schools
Source: Author's Field work (2014)

It was also observed that 9 (90%) of the 10 lecturers teaching structures across the four universities are males, while just 1(10%) is a female. While the gender imbalance as observed is not unusual, noting that previous studies have shown that architecture is a male dominated profession (Fowler and Wilson, 2004), this study further validates this position and also arouses curiosity as to the following:

i. Gender and Structures in architectural education
ii. Gender and mathematics inclined professions
iii. Gender and technical disciplines

These and a few more issues could be areas for further research.

4.3.6 Age Distribution of Faculty

The findings in Figure 4.10 show that 40% of the lecturers were in the age bracket of 31-40 years and 30% were between 51-60 years, 20% between 51 years and 60 years range and 10% in the 31-40 years range. Another perspective at this data using just two categories that is, 21-

40 years (50%) and 41-60 years (50%) shows equal distribution of 50% across the two categories. The observed trend where the age distribution is not lopsided is good, where the faculty members are not composed of only the old (experienced and possibly ageing towards retirement with possibly dwindling energy) or only the young or middle-age (moderate experience and with a lot of energy). This is a desirable trend and it should be encouraged as it has great potentials for a balanced view of architectural education.

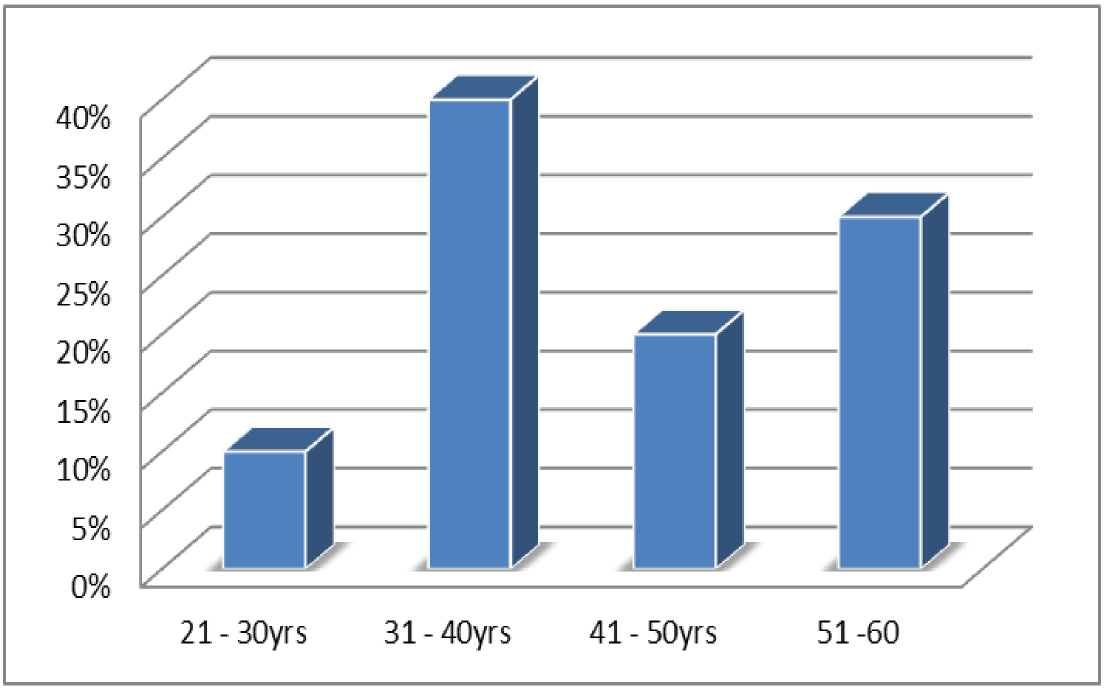

Figure 4.10: Age Distribution of Faculty
Source: Author's Field work (2014)

4.3.7 Educational Qualification of Faculty Members Teaching Structures

Examination of Figure 4.11 shows the distribution of the highest educational attainment of structures faculty across the four universities sampled surveyed. Figure 4.11 indicates that a majority (50%) of the faculty have Ph.D degrees while 40% have masters degree and 10% have other qualifications. The result suggests a fair distribution of educational qualification. While the minimum qualification required for teaching in the Nigerian University system is a

Ph.D, master's degree holders are encouraged to start as Assistant Lecturers and immediately commence and complete a Ph.D. The finding suggests that structures faculty possess the basic educational qualification and this trend is therefore recommended and can be improved.

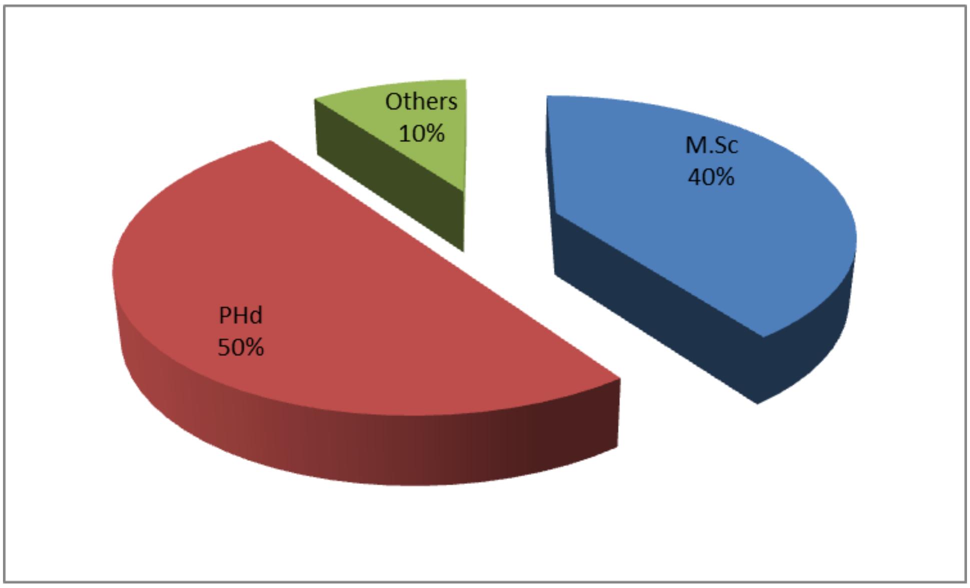

Figure 4.11: Highest Educational Attainment of Faculty
Source: Author's Field work (2014)

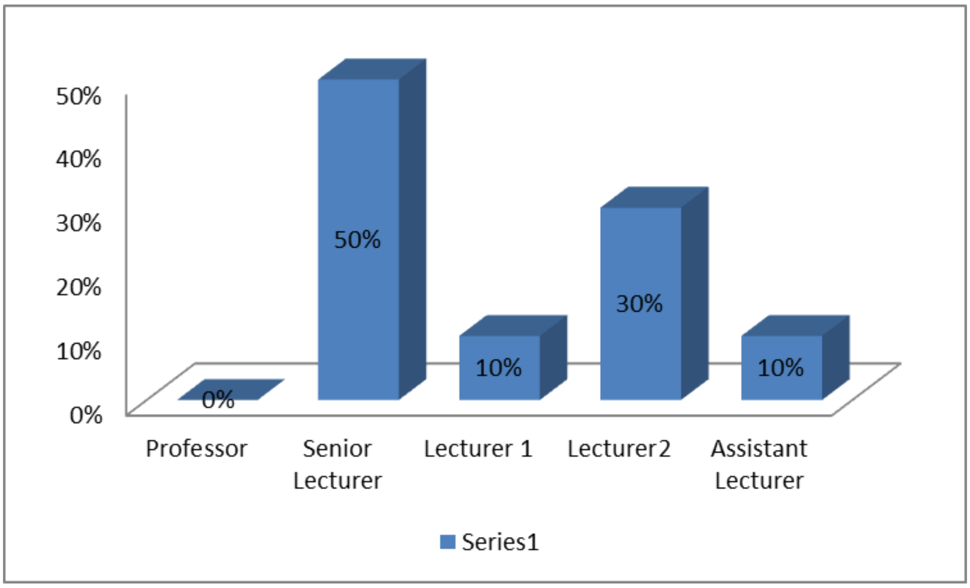

Figure 4.12: Designation of Structures Faculty
Source: Author's Field work (2014)

4.3.8 Designation (Academic rank) of Faculty

The data in Figure 4.14 on the designation of faculty members shows that 50% of structures faculty were Senior Lecturers, 30% were Lecturer 2, 10% Lecturer 1 and 10% were Assistant Lecturers. This result above suggests a good mix in cadre of faculty and the availability of the requisite manpower for a wholesome architectural education.

4.3.9 Profession of Faculty Teaching Structures

The result of analysis of the profession of structures lecturers across the four universities in Figure 4.13 shows that 70% of them are architects, 20% are builders, while 10% are civil/structural engineers. Also CU and FUTA have 100% of structures lecturers as architects, while UNILAG has 50% of structures lecturers as architects and the other 50% as Civil/Structural Engineers. However OAU has 100% of structures lecturers as builders (non-architects). The general result of 70% of structures lecturers as architects suggests that there is a consensus in the teaching approach that architects might be better teachers of architectural structures as advocated by emerging thoughts in architectural education.

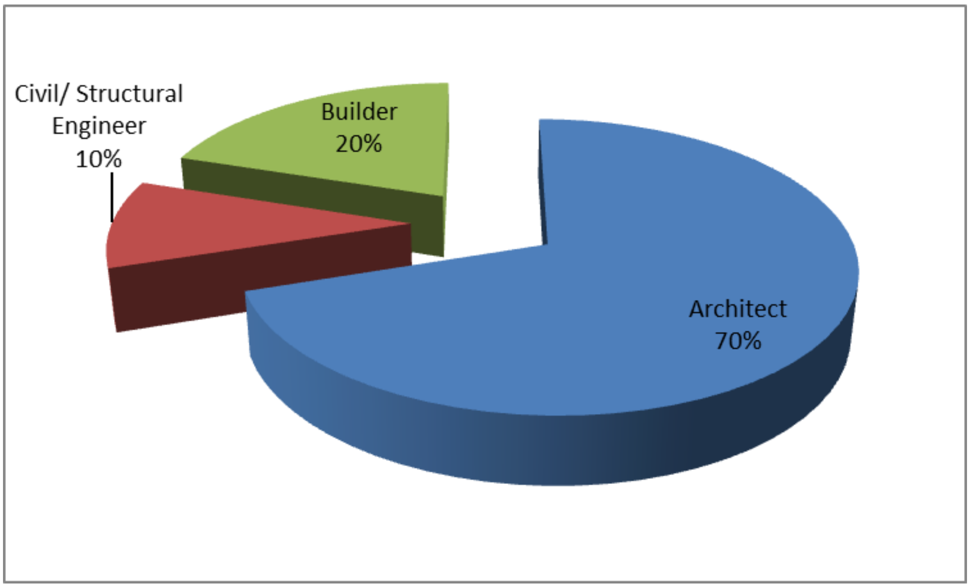

Figure 4.13: Profession of Structures Faculty
Source: Author's Field work (2014)

It also suggests a departure from the previous ideology of structures being taught by Civil/Structural Engineers and thus leaving the students to purely engineering based approach. While this departure is absent in OAU, where 100% of her structures lecturers are builders (non- architects), CU has embraced a full departure with 100% of her structures lectures as architects. It is therefore recommended that this trend be encouraged across other schools of architecture to facilitate improvement in structures instruction.

As part of the measures to assess the overall profile of faculty members, respondents were asked to indicate Yes or No, if they have undertaken any educational training in education/teaching. Figure 4.14 shows that 80% of lecturers have never undertaken any training course in education, while 20% have done so. This result suggests that a major gap in architecture education across the four universities surveyed and possibly a reflection of the entire university educational system where lecturers whose core business is teaching do not have any basic training in education. With the concept of academics being engaged in teaching and research, it may be said that faculty members are ill prepared for the task of teaching.

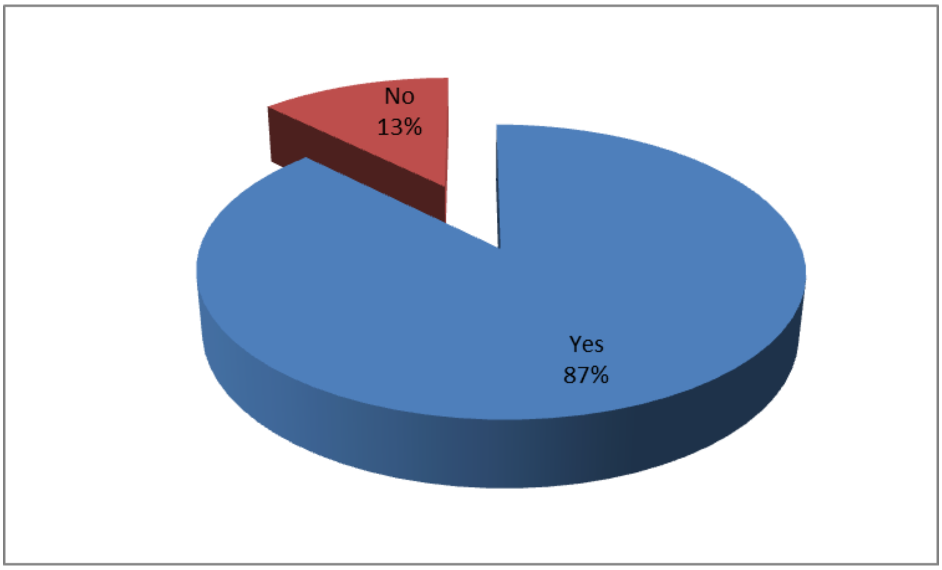

Figure 4.14: Educational Training of Faculty
Source: Author's Field work (2014)

4.3.10 Teaching Experience of Faculty

Figure 4.15 shows the distribution of the teaching experience of structures faculty across the four universities surveyed. Examination of Figure 4.15 shows a fair distribution of 40% of the faculty having 6 years and 10 years experience of teaching structures, 30% have above 10 years while the other 30% have 1 year and 5 years experience. This result suggests the availability of the requisite capacity for teaching especially a good mix in the years of experience, which allows the students to be exposed to varied teaching ideologies as may be encapsulated in the varied experiences of their teachers.

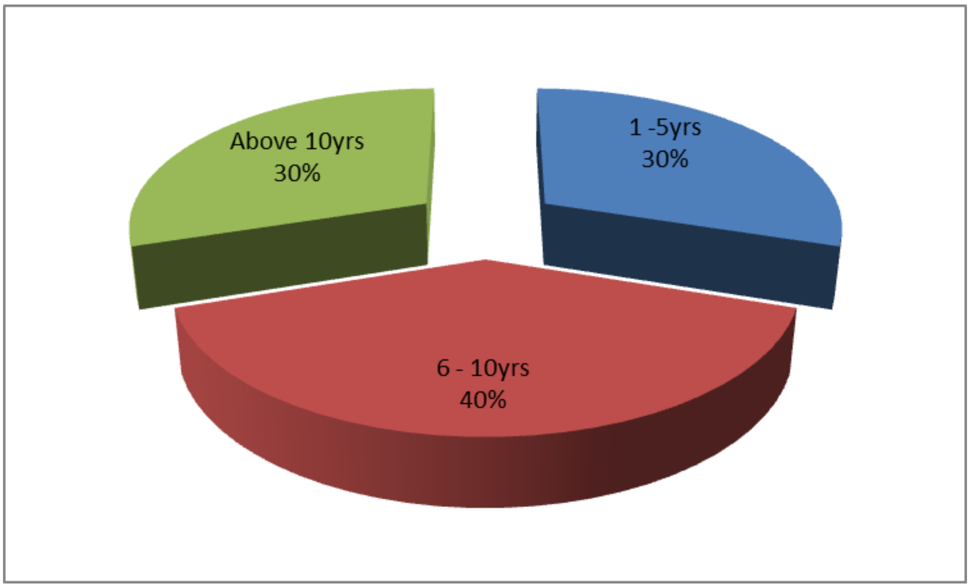

Figure 4.15: Teaching Experience of Faculty
Source: Author's Field work (2014)

4.4 The Use of ICTs In Teaching Architectural Structures

This section of the study assessed the degree of use of Information Communication Technologies (ICTs) in the teaching of Architectural Structures in the four universities sampled. The significance of this section lies in the potential of ICTs to transform education.

Wang (2009) observed two recurring themes in the use of ICTs in education. First is that ICTs have the potential to radically transform educational practice (classroom practice), and also promotes the constructivist paradigm of epistemology. It was therefore of interest to this researcher to investigate the different aspects of ICTs that are deployed in teaching architectural structures in the four universities surveyed. The result on the use of Information Communication Technologies derived from faculty and students is shown in Table 4.22. The mean score of responses from faculty is shown in learning input index (LII), while the mean score of responses from students is learning outcome index (LOI).

The mean of learning input index and learning output index is given as learning yield index (LYI), while the difference is given as learning efficiency index (LEI).

Table 4.22 Degree of Usage of ICTs for Teaching Structures

S/N	USAGE OF ICTs FOR TEACHING STRUCTURES	Faculty (A) Learning Input Index (LII)	Student (B) Learning Outcome Index (LOI)	$\frac{(A+B)}{2}$ Learning Yield Index (LYI)	Variance (B-A) Learning Efficiency Index (LEI)
1.	Use of Digital Media/Multi-media/ Audio-visuals in teaching (PowerPoint, Slideshare etc)	4.00	2.99	3.50	-1.01
2.	Use of online resource materials (e-books, courseware)	4.00	2.98	3.49	-1.02
3.	Use of internet	3.33	2.97	3.15	-0.36
4.	e-learning platforms	3.40	2.47	2.94	-0.93
5.	Use of Structural Analysis & Modelling Software Applications	1.75	2.42	2.09	0.65
6.	Social Media- (Facebook, Tweeter, Google^{+}, etc)	1.25	2.29	1.77	1.04
7.	Lecturer's website/Course website	3.00	2.27	2.64	-0.73
	Total Mean	**2.96**	**2.63**	**2.79**	**-0.33**

Source: Author's Field work (2014)

i. The Use of Digital Media/Multimedia

The LII of 4.00 indicates that faculty members claim that the usage of digital media is high, while the LO1 at 2.99 shows that students claim a moderate use. The LYI at 3.50 indicates a slightly high usage generally among students and faculty, while a variance (LEI) of -1.01 implies a sharp disagreement between the faculty and students on the degree of usage of digital media.

ii. The Use of Online resources

With an LII of 4.00, the claim of use of online resources by faculty is high, while an LOI of 2.98 indicates that the students think otherwise. The students claim that the use of online resources is moderate. The LYI of 3.49 among students and faculty, while a variance (LEI) of -1.02 shows a sharp disagreement between faculty and students on the degree of usage of online resources for teaching structures.

iii. The Use of Internet

Examination of the data on the use of the Internet in teaching structures shows an LII of 3.33, indicating a moderate degree of use and an LOI of 2.97 corroborate this position. An LYI of 3.15 further corroborates the earlier position that the use of the Internet is moderate among faculty and students. The LEI of -0.36 indicates a marginal disagreement on the actual degree of usage.

iv. The Use of Electronic-learning platforms

The result of the analysis of the data on the use of electronic learning platforms shows an LII of 3.40, indicating a moderate degree of usage, while an LOI of 2.47 indicates a low degree of usage. With an LYI of 2.94, it is clear that the degree of usage of electronic learning platforms is low. The LEI of -0.93 implies that, while there is a consensus on the low usage of electronic learning platforms, there is a sharp disagreement on the actual degree of usage.

v. *The Use of Structural Analysis and Modelling Software Applications*

The LII of 1.75 indicates that faculty claim that the usage of structural analysis and modeling software is very low, while the LO1 at 2.42 shows that students also claim a low degree of use of structural analysis and modeling software application. The LYI at 2.09 corroborates the position that usage of structural analysis software is low among the students and faculty in the four universities surveyed. Indeed it can be said to be non-existents, as none of the students and faculty surveyed indicated the name of any software used either in the teaching and learning of structures. A positive value for the variance (LEI) of 0.65 implies an inclination on the part of the students towards its usage. The most critical finding here is that none of the respondents- students and faculty were able to indicate the structural analysis and modeling software they use. The implication of this is that there is no use of structural analysis software in the teaching and hearing of structures in the departments of Architecture in the four universities investigated.

In addition, faculty members were asked on the possible use of software application in teaching structures.

vi. *The Use of Social Media Platforms*

Examination of the data on the use of social media platforms in teaching structures shows an LII of 1.25, indicating a very low degree of usage and an LOI of 2.29 corroborate this position. An LYI of 1.77 further corroborate the earlier position that the use of the social media among faculty and students. The positive value of 1.04 for the LEI indicates an inclination and a preference by students for the usage of social media platforms in the teaching and learning of architectural structures.

vii. The Use of Lecture's website/ Course website

The result of the analysis of the data on lecturer's/ course website shows an LII of 3.00, indicating a moderate degree of usage, while an LOI of 2.27 indicates a low degree of usage. With an LYI of 2.64, it can be seen that the degree of usage is low. With no faculty providing their website address it can be implied that the usage of this ICT tool is non-existent in the teaching of structures in the four departments surveyed.

Generally, the mean scores of the LII, LOI and LYI for all ICT tools investigated are 2.96, 2.63 and 2.79, respectively. The fact that these three means are less than the 3.00 mid- value mark implies that the degree of usage of ICTs in teaching architectural structures in the four universities surveyed is low. However, Dirckinck-Holmfeld and Lorensten (2003) observed from their teaching experience that ICTs indeed have the potential to transform education by making it interactive. Wang (2009) observed that architecture schools have used ICT to transform both architectural imagination and architectural practical possibilities.

In addition to the recent developments in digital technology, Vassigh (2001) developed a series of digital animation instructional tools for teaching structures. He shared more insight on the use of computer-generated models, interactive images, and animation, integrates quantitative engineering methods with qualitative approaches with a wide range of digital visualization devices. He also argued that by explaining working principles with audio, students could focus on the animation and directly connect complex structural concepts with the visually demonstrated material or structural system performance, rather than extrapolating these ideas from written text and mathematical symbols. He therefore stated that one of the greatest advantages of using digital animation technology is that *it enables us to fabricate visual environments custom made to demonstrate complex concepts in an easy to understand visual means.* The manipulability of these environments to emphasize or de-emphasize certain structural members further accentuates its teaching capability.

Three core educational values of computer analysis for teaching structures can be identified from the work of Black and Duff (1994) to include:

i. Speed up lengthy computations and increase analytical accuracy,
ii. It can provide students with a direct shortcut to gaining an understanding of structural, behavior without years of background preparation.
iii. The relative merits of various structural systems can be compared in real terms, and the feasibility of design ideas can be tested concretely, regardless of their complexity.

They reported the effects of computer analysis and simulations by noting that:

i. If intelligently guided, students can gain more direct experience of structural behaviour through the use of computer analysis in a one-semester university course than they would normally get in years of practice.
ii. The ability of the computer to display deformed shapes rapidly allows students to study structural behaviour from a kinematic point of view, rather than solely in terms of forces and load paths.
iii. The activity of “zooming”, in which attention is repeatedly shifted between local considerations and global considerations, is practically forced on the students, as they must continually check the individual members for overstressing and buckling while they design and study the global structure.

iv. Students are able to study structures in the context of design, as the computer can be taken into a design setting and used as a design tool. Students then find themselves studying structures on their own turf, rather than in the alienating and isolated territory of math-oriented engineering, and can realistically consider structure and structural behavior in the earliest, inventive stages of their work. Moreover, the continuing iterative cycling and refinement of architectural ideas can be exactly paralleled to a sequence of structural analyses, and as design iterations unfold, structural analysis can continue alongside architectural design in a truly integrated fashion.

v. The most notable effect of using the computer in the classroom is that it really can be used as a tool for discovery, as it transforms a course from one in which students are passively receiving information and solving artificial and empty problems into one in which they are actively engaged in finding things out for themselves.

4.5.0. Asssessment of The Impact of Learning Inputs, Students Profiles And Learning Environment On Learning Outcome

The goal of this section is to present and discuss the result of the analysis carried out to examine the impact of learning inputs, students' profile and learning environment on the learning outcomes in architectural structures in the four universities investigated. Bulk of the data used was derived from the students' and faculty members' questionnaire. The section begins with the overall assessment of the components of the learning inputs, students profile and learning environment which represent the independent variables, while the learning outcomes, was the dependent variable. The next section attempts to sieve out the significant independent variables that influence the dependent variable. In other words the predictors of learning outcomes of architectural structures were identified and their implications discussed. The section concludes with a summary of the findings.

4.5.1 Overview of Learning Inputs, Students' Profile and Learning Environment

The presentation and discussion of result of analysis of learning inputs, students profile and learning environment in this study involve the presentation of data on their respective components and the attribute mean scores as presented in Table 5.1. In this study, learning inputs represent teaching approaches, curriculum and students perception of the teaching approaches. The teaching approaches were further categorized into four main types, from a pool of nine instructional strategies. These include lecture-based instruction, project based instruction, case based instruction and visual based instruction. The curriculum in this study was measured by the relative weight of structures credits units in the overall graduation benchmark for architecture. Students' profiles were defined in terms of demographics, personal profiles and learning styles. The learning environment was described in terms of the extent of usage of information communication technologies in the teaching of architectural structures.

4.5.2 Dimensions of Learning Outcome

For the purpose of this study, learning outcome in structures course was assessed from two dimensions. First, was test scores (last semester grade of each student) which is a measure of the students knowledge in structures, that is how literate the students are in structures. To this end, the test score was used to assess the *structural literacy* of the students. Second, was application of structures knowledge to design studio (application of acquired knowledge to solving problems- problem solving skills). This is a measure of how competent the students are in the use of acquired structures knowledge to solve problems in the design studio. This has been referred to as higher order skills. In the context of this study and the related field of pedagogy of structures, this is known as *structural competence* (see in Figure 5.1).

4.5.3 Factors Influencing Structural Literacy: Learning Outcome (measured by Test Score)

Categorical Regression Analysis was performed using the optimal scaling method with the criteria for convergence set at 0.00001. In performing this analysis, *Learning Outcome*: Structural Literacy (measured by Test Score-Last Semester Grade) was the dependent variable and the respective components of *learning inputs*, *learning environment* and *students' Profile* were the predictors (independent) variables. The learning inputs were categorized into *teaching approaches* (lecture based instruction, project based instruction, case based instruction and visual based instruction), *curriculum* (measured by relative weight of structures credit units to the architecture graduation benchmark) and *students perception* (area of emphasis in teaching, elevance of structures to design studio, level of interest, teaching approaches and content). The learning environment was described as usage of ICTs with components as: The use of digital media/multi-media/ audio-visuals in teaching – (powerpoint, slideshare etc), The use of online resource materials (e-books, courseware), Use of internet, e-learning platforms, The use of structural analysis & modelling software applications, Social Media- (Facebook, Tweeter, Google^{+}, etc) and Lecturer's website/Course website). students' profile was categorized into demographics, personal profile and learning style. Demographics had sub-components as level of study, gender, age group and student overall academic performance (CGPA). Personal profile had two sub-components of extroversion-introversion and sensing-intuition, while learning style also had two sub-components of accommodator-assimilator and diverger-converger.

The result of the categorical regression analysis shows that Adjusted R^2 value= .235. Table 4.27 shows the levels of contribution of each predictor in explaining the dependent variable. It can be seen from Table 4.27 that of the 19 independent variables included in the regression model, only 2 were significant predictors of learning outcome (structural literacy). The variables in the order of their contribution are students overall academic performance (Beta= 0.287, F= 17.002, P=0.000) and Level of Interest (Beta=0.340, P=0.000).

Table 4.23: Regression Coefficients of Predictors of Structural Literacy: Learning Outcome (measured by Test Score)

Independent Variables	Standardized Coefficients		Df	F	Sig.
	Beta	Std. Error			
Lecture Based Instruction	-.083	.136	2	.377	.686
Project Based Instruction	.143	.209	3	.472	.702
Case Based Instruction	.193	.272	4	.503	.733
Visual Based Instruction	-.193	.229	3	.710	.547
Curriculum- Relative weight of Structures credit units to graduation benchmark	.123	.092	1	1.790	.182
Use of ICT	-.142	.181	2	.618	.540
Level of Study	-.102	.149	2	.468	.627
Gender	.008	.047	1	.029	.864
Age grouping	.115	.154	1	.559	.455
Students Overall Academic Performance (CGPA)	.287	.070	2	17.002	.000*
Personal Profile (Extrovert-Introvert)	-.058	.141	1	.166	.684
Personal Profile (Sensing- Intuition	-.086	.126	2	.465	.629
Learning Style (Diverger-Converger)	.095	.142	3	.446	.720
Learning Style (Accommodator-Assimilator)	.116	.174	3	.447	.720
Area of Emphasis in teaching	.029	.108	2	.070	.932
Relevance of Structures to Design Studio	.092	.148	2	.387	.679
Level of Interest	.340	.091	3	13.837	.000*
Student Perception of Teaching Approaches	.144	.173	4	.695	.596
Student Perception of Content	-.184	.150	3	1.519	.210

Dependent Variable: Structural Literacy (measured by Test Score-Last Semester Grade)
*Significant P<0.005
Source: Author's Field work (2014)

It is interesting to note that the other 17 variables do not make significant contributions to structural literacy (measured by test scores/grades). These two predictors have relevant implications in the teaching of structures. These implications will be discussed in the consequent sections.

4.5.4 Factors Influencing Structural Competency: Learning Outcome (measured by Application of Structures Knowledge to Design Studio)

The same procedure of categorical regression analysis performed previously for the structural literacy component of the learning outcome was also performed to determine the factors influencing the structural competency component of the learning outcome. In performing this analysis, *Learning Outcome*: Structural Competency (measured by Application of Structures Knowledge to Design Studio) was the dependent variable and the respective components of *Learning Inputs*, *Learning Environment* and *Students Profile* were the predictors (independent) variables.

It can be seen from this Table 4.28 that of the 19 independent variables included in the regression model, five were significant predictors of learning outcome (structural competence). The variables in the order of their contributions are: Relevance of Structures to Design Studio (Beta= 0.528, P=0.000), area of emphasis in teaching students (Beta=0.340, F=3.440, P=0.017), project based instruction (Beta= -0.246, P=0.015), personal profile: Sensing/Intuition (Beta= 0.145, P= 0.034), students overall academic performance (Beta= -0.108, P=0.035).

Table 4.24: Regression Coefficients of Predictors of Structural Competency: Learning Outcome (measured by Application of Structures Knowledge to Design Studio)

Independent variables	Standardized Coefficients		Df	F	Sig.
	Beta	Std. Error			
Lecture Based Instruction	.119	.100	3	1.418	.238
Project Based Instruction	-.246	.138	4	3.158	.015*
Case Based Instruction	.033	.181	2	.033	.967
Visual Based Instruction	.065	.141	3	.212	.888
Curriculum -Relative weight of Structures credit units to graduation benchmark	.043	.070	2	.371	.691
Use of ICT	.225	.134	2	2.798	.063
Level of Study	.039	.084	2	.220	.803
Gender	.016	.032	1	.238	.626
Age grouping	.072	.105	1	.469	.494
Students Overall Academic Performance (CGPA)	-.108	.063	3	2.902	.035*
Personal Profile (Extrovert-Introvert)	-.079	.099	4	.632	.640
Personal Profile (Sensing- Intuition)	.145	.078	2	3.418	.034*
Learning Style (Diverger-Converger)	-.151	.160	3	.890	.447
Learning Style (Accommodator-Assimilator)	-.019	.130	3	.022	.996
Area of Emphasis in teaching	-.131	.071	3	3.440	.017*
Relevance of Structures to Design Studio	.528	.074	4	50.180	.000*
Level of Interest	.160	.100	3	2.577	.054
Student Perception of Teaching Approaches	.058	.168	1	.120	.729
Student Perception of Content	.039	.130	1	.089	.766

Dependent Variable: Application of Structures Knowledge to Design Studio.

*Significant $P<0.005$

Source: Author's Field work (2014)

4.5.5 Factors Influencing Structural Proficiency: Learning Outcome (measured by a combination of Test Score and Application of Structures Knowledge to Design Studio)

The predictors of the two dimensions of learning outcome in structures instruction, namely, structural literacy and structural competence (two different dependent variables) measured by test score and application of structures knowledge to the design studio respectively were examined earlier. In a bid to properly situate the objective of this study, which is to identify ways of improving interest and understanding of the subject of structures, it becomes necessary to narrow the study to a single dependent variable with which other variables can be regressed. Thus, a new dependent variable, structural proficiency was developed as a combination of structural literacy and structural competence. The data set was therefore further analysed with Categorical Regression Analysis. The result of the analysis is presented in table 4.25.

The result shows that much of the variance in the dependent variable is explained by the regression model with Multiple R = 0.669, Adjusted R Square = 0.352 and the R Square value of 0.447.This implies that the regression model used explains about (45%) 44.7% of the variance in structural proficiency. The result (F=8.090, P=0.000) also implies that the result is statistically significant at P<0.0005. It can be seen from Table 4.29 that of the 19 independent variables included in the regression model, only 6 were significant predictors of structural proficiency. The variables in the order of their contributions are Student Perception of Content (B=0.307, P=0.000), level of interest (B = 0.271, , P=0.004), visual based instruction (B=0.164, P=0.03), relevance of structures to design studio (B = 0.156, P=0.033), Learning Style (Accommodator-Assimilator) (B= 0.155, P=0.001), personal profile (extrovert-introvert) (B= -0.136, P=0.002).

Table 4.25: Regression Coefficients of Predictors of Structural Proficiency: Learning Outcome (measured by a combination of Application of Structures Knowledge to Design Studio and Test Score)

	Standardized Coefficients		DF	F	Sig.
	Beta	Std. Error			
Lecture Based Instruction	.075	.071	2	1.099	.335
Project Based Instruction	-.132	.085	2	2.424	.091
Case Based Instruction	-.067	.133	2	.253	.777
Visual Based Instruction	.164	.081	4	4.063	.003*
Students Perception of Teaching Approaches	.023	.193	2	.014	.986
Students Perception of Content	.307	.077	3	15.891	.000*
Use of ICT	.064	.105	1	.369	.544
Personal Profile (extrovert-introvert)	-.136	.066	4	4.251	.002*
Personal Profile (Sensing-Intuition)	.100	.107	2	.877	.417
Learning Style (Diverger - Converger)	-.048	.117	2	.168	.846
Learning Style (Accommodator-Assimilator)	.155	.067	3	5.369	.001*
Curriculum- Relative weight of Structures credit units to graduation benchmark	.045	.073	2	.378	.686
Level of Study	.113	.086	2	1.730	.179
Gender	-.066	.058	2	1.301	.274
Age Grouping	-.012	.111	1	.012	.912
Students Overall Academic Performance (CGPA)	.090	.056	2	2.551	.080
Level of Interest	.271	.126	3	4.641	.004*
Relevance of Structures to Design Studio	.156	.090	3	2.964	.033*
Area of emphasis in teaching	-.088	.101	3	.757	.519

Dependent Variable: Structural Proficiency: Overall Learning Outcome (measured by a combination of Application of Structures Knowledge to Design Studio and Test Score)
*Significant P<0.005
Source: Author's Field work (2014)

4.6 Chapter Summary

This chapter was a presentation of the results and analysis of data in this study. These include evaluation of the structures curriculum, assessment of teaching approaches and students perceptions, profiles of students and faculty, use of ICTs. Findings of the impact of the learning inputs, students' personality profile and learning environment on learning outcome were also presented. From the result, the following key findings emerged.

First, structures as a course of study is domiciled under the building construction technology module, with the objective of developing among others the understanding of components of buildings, the structure and the process involved in putting them together to realize an architectural piece.

Second, the content of the NUC curriculum appears broad (not detailed and specific), and thus leaving room for subjective interpretations of the benchmark by the different schools. It was observed that comparing the 5 semesters (a total of 10 units) in FUTA and UNILAG to the 6 semesters (17 units) and 7 semesters (18 units) for OAU and CU respectively clearly shows that the curricula of FUTA and UNILAG are characterised by brevity while that of the OAU and CU characterised by depth and thoroughness of scope. The sequence of the curriculum was found to be the same across the four universities surveyed and more importantly identical to the classical sequence of presenting physics, statics, and strength of materials, analysis and "design" which though represents a logical progression of information has been divorced from involvement with the total process of architectural design.

Third, the study also found that the emphasis of the curriculum was divergent across the four universities studied. FUTA and UNILAG curricula appear to be inclined more towards the architecture polarity (theory), while those of CU and OAU appear to be inclined more towards the engineering polarity (calculation). Also the relative weight of the structures credit units in the overall graduation benchmark for architecture was observed to be 6.85% for the NUC-BMAS, CU and OAU have similar weights of 6.49% and 7.69%, respectively, while FUTA and UNILAG were observed to have similar weights of 4.23% and 4.69%, respectively. In addition, it was observed that the learning outcomes, which were measured on two scales of; structural literacy (acquisition of structural knowledge) SKI and structural competence (ability to use and apply structural knowledge to solve design problems) (SII) have a mean score of 0.790, and 0.71, respectively. It was observed that the SKI is higher than the SII in each of the four universities investigated.

Fourth, it was also observed that a majority (62.4%) of the architecture students surveyed are extroverts (who focus on external reality and direct their attention toward people and objects and are experiential learners, learn best by hands-on exercises and activities), while 37.6% are introverts. Similarly, a majority (72.8%) of architecture students encountered in this research were sensers (*concrete learners*-who rely on one or more of the five senses to interprete facts or events), while 27.2% are intuitors (*abstract learners that* tuned to conceptual and theoretical issues). The learning style profiles of the students were observed to be majorly divergers (35.59%) and accommodators (35.24%) characterised by concerete experience (CE) as contrasted to convergers (14.41%) and assimilators (14.76%), characterised by abstract conceptualization (AC). Regarding the professional inclination of faculty teaching architectural structure, majority (70%) of structures lecturers were architects, while 30% were engineers and builders. It was also observed that 80% of the faculty members have never undertaken any educational training course.

Fifth, of the nine teaching approaches evaluated, lecture was found to be the most predominant teaching approach, followed by tutorials. The group-based project approach, was fairly used teaching approach in the delivery of structures instructions. Its effectiveness is inherent in its potential to promote concrete learning as against abstraction.

Sixth, a majority of the students perceived structures as placing emphasis on calculations/analyses .They also agreed that it was relevant to their study of architecture and the design studio. A significant proportion of the students do not find structures to be as interesting, practical and easily applicable. Also a majority of the students claimed that they do not apply what they learnt in structures to their design studio work, thus suggesting a disconnect between what is taught in structures and the design studio. Also the students generally perceived the subject areas to be increasingly difficult as they progress to higher levels in their studies. The result of the analysis further showed that 43% of the students would rather not choose structures if made optional, while 57% would choose it as one of their courses.

Seventh, the result also reverted that the degree of use of ICTs in the teaching of structures across the four universities surveyed was very low. This is particularly evident in the use of software for structural analysis and modeling.

Lastly, using categorical regression analysis, it was found that only six of the nineteen variables investigated emerged as predictors of learning outcome. The variables in the order of their contributions are Student Perception of Content (B=0.307, P=0.000), level of interest (B = 0.271, , P=0.004), visual based instruction (B=0.164, P=0.03), relevance of structures to design studio (B = 0.156, P=0.033), Learning Style (Accommodator-Assimilator) (B= 0.155, P=0.001), personal profile (extrovert-introvert) (B= -0.136, P=0.002). The findings essentially imply that improving learning outcome in structures instruction requires that adequate and appropriate attention be given to each of the predictors identified in this study.

CHAPTER 5

DISCUSSION

5.0 Introduction

This chapter is an attempt to summarize and examine the implications of the findings of this study. It is made up of five main segments. The first discusses the findings on curriculum evaluation while the second discusses teaching approaches and students' perception. The third segment is a discussion on the personality profile of the students (demographics, personality characteristics and learning styles). An assessment of the use of ICTs is discussed in the fourth segment. The fifth segment discusses the impact of the learning input, students' personality profile and learning environment on learning outcome.

5.1 Curriculum Evaluation

Curriculum evaluation described as *the assessment of the merit and worth of a program of studies, a field of study, or a course of study (*Glatthorn, *et al.*, 2012) was evaluated using the four dimensional Stufflebeam's (CIPP) Model of *context, input, process and product.* The structures curriculum was drawn from the National Universities Commission (the regulatory body for university education in Nigeria) benchmark minimum academics standards (NUC-BMAS) and the academic handbooks of the four schools surveyed.

The context dimension was evaluated by examining architectural education (aim, objectives, philosophy and subject regime) in Nigeria. It was observed that the aim of architectural education in Nigeria was to ensure that a graduate of architecture was well trained in the art and science of planning, design, erection, commissioning, maintenance, management and co-ordination of allied professional inputs in the development of the environment. The development of the courses should be flexible enough to allow for the changing needs of architectural education arising from changing social, economic, psychological and technological environment. It is expected that all the programmes will ensure that students are instructed in the main aspects of Architecture: a) architectural design b) communication skills c) history and theoretical studies d) building construction technology e) arts and humanities f) Environmental Services g) Physical Sciences and Information Technology h) Management Studies and Entrepreneurship Studies. Structures as a course of study was identified to be domiciled under the building construction technology module, which has the objective of developing among others the understanding of components of buildings, the structure and the process involved in putting them together to realise an architectural piece.

The input dimension of the curriculum was examined under three sub-themes namely; the content of the curriculum, the sequence of the thematic areas and the emphasis of the curriculum. The content of the NUC curriculum appears broad (not detailed and specific) thus leaving room for subjective interpretation of the benchmark by the different schools. Comparing the 5 semesters (a total of 10 units) of FUTA and UNILAG to the 6 semesters (17 units) and 7 semesters (18 units) for OAU and CU, respectively, it was observed that the curricula of FUTA and UNILAG are characterised by brevity while those of the CU and OAU is characterised by depth and thoroughness of scope.

The sequence of the curriculum was found to be the same across the four universities surveyed and more importantly identical to the classical sequence of presenting physics, statics, and strength of materials, analysis and “design” which though represents a logical progression of information has been divorced from involvement with the total process of architectural design. This sequence has been criticized as producing architectural graduates who have no understanding of the basic principles involved, cannot apply them, nor retain for a significant period after graduation the basic core of material encountered (Richard Bender, 1976 cited by Black and Duff,1994). This is consistent with the position by the American Collegiate Schools of Architecture (ACSA) on the adverse effects of the classical sequence. It is also in tandem with Black and Duff (1994) on the study of global behaviour (as against component member behaviour). The concept of parti pris pedagogy (Hedges, 2014) with a focus on the concept of central idea respectively as against incremental mastery and gradual accrual of structural knowledge that is independent and disconnected from its purpose of complementing the architectural design process further validates the above finding. It was thus obvious that the observed trend in the sequence of structures curriculum across the four universities that is typical of the classical structures sequence suggests a need for a rethink.

The emphasis of the curriculum was found to be divergent across the four schools. FUTA and UNILAG curricula appeared to be inclined more towards the architecture polarity (theory), while those of CU and OAU appeared to be inclined more towards the engineering polarity (calculation). It was therefore evident in this study that there is a divide in the structures pedagogy in the universities investigated. The impact of this divide was succinctly captured by Black and Duff (1994) as previously highlighted.

The process dimension examined requisite Architectural structures course credit units system and graduation benchmark. The relative weight of the structures credit units in the overall graduation benchmark for architecture was examined across the four universities surveyed and benchmarked with the NUC-BMAS. It was observed that while the NUC-BMAS has a 6.85% weight, CU and OAU have similar weights of 6.49% and 7.69%. FUTA and UNILAG were observed to have similar weights of 4.23% and 4.69% respectively. From the findings of the process dimension, the relative importance of structures in the general curriculum of architectural education can easily bee seen.

The product dimension evaluated the learning outcomes, which measured structural literacy (acquisition of structural knowledge) and structural competence (ability to use and apply structural knowledge to solve design problems). Structural literacy was measured by structural knowledge index (SKI) using test scores, while structural competence was measured by structural intuition index (SII) using students application of knowledge gained in structures class to design studio. It was observed that the SKI was higher than the SII in each of the four universities. Also the mean SKI (0.790) was higher than the mean SII (0.716). It is therefore evident from this study that there is a significant gap between what is learned and to what extent students apply what is learnt. This implies that the students are more structurally literate than they are structurally competent because structural competence was found to be lower than structural literacy among the students surveyed across the four universities surveyed. This should not be the case, since structural competence is the preferred learning outcome of structures instruction.

5.2 Teaching Approaches in Architectural Structures

Generally, the nine teaching approaches evaluated across the departments of architecture in the four universities, can be categorized into four major groups. These are lecture-based instruction, project-based instruction, case-based instruction and visual-based instruction as shown in Table 5.1. Lectures were found to be the most predominant teaching approach, followed by tutorials. Group Based Project was fairly used, study of structural failures, study of historical structures, usage of graphics (sketches and pictures), use of models, case studies from practice and laboratory tests and investigations were rarely used. While the lecture-based approach is the most predominant mode of instruction in the four universities surveyed, recent studies have criticized its effectiveness in communicating structural knowledge.

Table 5.1: Summary of Teaching Approaches

S/N	Teaching Approaches	Faculty (A) Learning Input Index (LII)	Student (B) Learning Outcome Index (LOI)	(A+B)/2 Learning Yield Index (LYI)	Variance (B-A) Learning Efficiency Index (LEI)
A	Lecture Based Instruction	4.72	3.80	4.27	-0.92
B.	Project Based Instruction	2.42	2.78	2.60	+0.36
C.	Case Based Instruction	3.55	2.89	3.22	-0.66
D.	Visual Based Instruction	3.15	2.91	3.03	-0.24

Source: Author's Field work (2014)

Its criticism stems from the fact that it is biased towards structural engineering that largely uses mathematical abstraction to communicate structural knowledge (Yazici and Yazici, 2013). Another criticism of the lecture-based approach is that it is averse to the accustomed mode of learning for architecture students, which is the architectural design studio, where they are used to a "learning by doing" approach. Noting that architecture students are favourable to the learning by doing approach, Yazici and Yazici (2013) noted that they have a hard time adjusting to regular classroom delivery of instructions which is primarily lecture-based.

The group-based approach, which is a fairly used teaching approach in the delivery of instructions, has been found to have potential instructional effectiveness. Its effectiveness lies in the fact that architectural education is inclined towards group-based project, which is an indicator of the diverger, and accommodator learning styles that has been associated with architecture students (Singhasiri, Darasawang and Srimavin, 2004, Tucker, 2007). The adoption of group-based project as a teaching approach is therefore recommended to improve instructional effectiveness in the teaching of structures.

Evidence from the literature also shows that a group of three of the rarely used teaching approaches- the study of historical structures, study of structural failures, case studies from practice - also have potential instructional effectiveness. They were found to promote student engagement thereby stimulating interest, aid student understanding of the fundamental structural principles and encourage a greater appreciation for the design potential associated with structural optimization.

Another set of two of the rarely used teaching approaches - usage of graphics and the use of models also have evidences of promoting visuo-spatial thinking as against mathematical thinking. These two teaching approaches become very significant to the teaching of architectural structures, because a fundamental goal of architectural education is to promote visuo-spatial thinking in students. Laboratory tests and investigation, the last of the nine teaching approaches investigated was found to be rarely used also has teaching effectiveness as evidenced from literature. Its effectiveness is inherent in its potential to promote concrete learning as against abstraction.

5.3 Students' Personality Profile

This section examined the profiles of architecture students and structures faculty across the four selected universities. The study examined the students personality profile from three perspectives namely demographics, personality characteristics and learning styles. The section identified that a majority (64.8%) of the students are males and 35.2% are females which is consistent with the position in the literature that architecture is a male dominated profession. The results also revealed that the majority (63.0%) of the students were in the age range between 19 years and 22 years, and confirmed that private universities attract a greater percentage of younger students. UNILAG and CU students were found to have higher academic performance. It can be inferred that these two universities have a robust academic environment capable of producing high performing students or that they are able to attract and recruit talented students.

The result of the orientation to life dimension of the personality profile indicates that a majority (62.4%) of the architecture students surveyed are extroverts, while 37.6% are introverts. With majority of the students as extroverts, characterised as experiential learners learning best by hands-on activities, improving learning outcomes in structures would require that teaching strategies should be designed to align with their personal preferences. Such may include the following: group based work, field trips/site visit, project based learning (learning by doing), and model making. It was observed that the principles of design studio is sympathetic to the learning preferences of extroverts, the design studio may improve learning outcomes in technical courses such as structures. Therefore, a design studio approach to teaching technology is advocated. It is an attempt at teaching technology in a design context and not as a separate course with a view to integrating technology courses into the design studio.

The finding of the perception dimension of the personality profile shows that a majority (72.8%) of architecture students sampled are sensers (concrete learners), while 27.2% are intuitors (abstract learners -tuned to conceptual and theoretical issues). With a majority of students being sensers, who rely on one or more of the five senses to interpret facts or events, they perceive the world by observing and gathering data through the senses, it is imperative that a corresponding teaching style should adopt concrete approaches that promote hands-on experience. This can be achieved by the use of models (physical or digital), experiments and facts.

The learning style profile of the students was observed to be majorly divergers (35.59%) and accommodators (35.24%) as contrasted to convergers (14.41%) and assimilators (14.76%). With Concrete Experience (CE) as the main distinguishing characteristic of the diverging and accommodating learning styles as contrasted with the converging and assimilating style characterised by abstract conceptualization (AC), concrete and experiential learning strategies must be weaved into the curricula and teaching of architectural structures.

The result of the data on gender of the members taking structures faculty also confirmed the male dominance of the architecture profession. An even distribution was identified in the age range of faculty, teaching experience, educational qualification and designation, which were seen as a desirable trend, and could enrich students experience through the varied teaching experiences of the faculty. It was also observed that 70% of structures lecturers are architects, which suggests that there is a consensus in the teaching approach that architects may be better teachers of structures than engineers as advocated by emerging thoughts in architectural education. However, it was observed that 80% of the faculty members have never undertaken any educational training course. The significance of this result may be a subject for further research.

5.3.1 Implications of The Personality Characteristics of Architecture students for the teaching of Architectural structures

(i) Pedagogical Implications of The Orientation to life of The Students:

The findings of this study show that 62.4% of the respondents' i.e a total of 193 students have an extroverted personality type, while 37.6% (116 students) have an introverted personality type. This result indicates that a majority of the architecture students sampled have an extroverted personality type. With the majority of the students as extroverts, the teaching strategies should be designed in a manner that aligns with their personal preferences and targeted at improving their learning outcomes.

Extroverts tend to focus on external reality (the outer world) and direct their attention toward people and objects. This implies that extroverts are experiential learners, and learn best by hands-on exercises and activities. Hence teaching strategies that would improve their learning outcomes should include the following:

i. Group based work,
ii. Field trips/site visit/academic excursion,
iii. Project based learning,
iv. Learning by doing,
v. Problem based learning, and
vi. Model making.

The dominance of the extroversion personality type among architecture students may suggest that the philosophy underpinning the pedagogical approach of the design studio – the principal subject of architectural education.. The design studio is principally taught using the principle of learning by doing, group work and other experiential learning strategies. It may thus be inferred that applying the design studio principles to other courses in architecture (especially technical courses comprising construction, environmental controls and structures as its core course), may help to improve learning outcomes, particularly noting that the principles of design studio is sympathetic to the learning preferences of the extroversion personality type. This approach is intended to provide the much needed integration of technology courses into the design studio. It is an attempt at teaching technology in a design context and not as a separate course. Some attempts that have been made in this area include the following:

i. The Total Studio (Levy, 1980)

ii. The Second Studio/Technology/Technical Studio (Allen, 1997)

iii. The Structures Project (Chiuini, 2006)

iv. The 2 plus 1 studio (Schoenefeldt, 2013) as previously discussed

(ii) Pedagogical Implications of The Perception dimension: Sensing vs Intuitive

From Table 4.19, it is evident that around 72.8% of the students belong to the sensing personality type, while 27.2% belong to the intuitive sensing personality type. This result indicates that a high majority of architecture students surveyed across the four universities are sensers. This finding also suggests that the teaching approaches should be tailored to suit the sensing personality type with some variants to accommodate the minority population of intuitive students. Sensers tend to rely on one or more of the five senses to interprete facts or events. They perceive the world by observing and gathering data through the senses, and are *concrete learners*. Intuitors on the other hand rely more on internal sources of information to interpret reality. They are engaged in indirect perception by way of the unconscious-speculation, imagination and hunches (Felder, & Silverman, 1988, O' Brien,. *et al.*; 1998). Put succinctly, they are *abstract learners*.

Noting that 72.8% of architecture students sampled are sensers, that is they are concrete learners, it thus becomes necessary that the corresponding teaching style should follow approaches that promote hands-on experience. This can be achieved by the use of models (physical or digital), experiments and facts. This is in contrast with intuitive learners who are more tuned to abstract- conceptual and theoretical- issues.

The result in Tables 4.17 and 4.19 is very relevant to the study of architectural structures, noting significant portions of the curriculum deals with abstract-conceptual and theoretical-issues. Yet the personality profiles of architecture students from the surveyed schools show that 72.8% are sensers, who are concrete learners and not abstract learners. This in itself is profound as the personality profile of the learners is in conflict with the course content and thus suggests a rethink of the curriculum or possibly the medium of communication and presentation of course content in structures.

5.3.2 Implications of The Learning Style of Architecture students for the Teaching of Architectural structures

The findings of this study validate the findings of previous studies such as Tucker (2007), which reported that the learning styles of architects were a little biased towards the upper left (north west, in the two-dimensional LSI cycle) of the Kolb typology. Learners such as these named as “accommodators”-i.e., people with the ability to learn from primarily “hands-on” experience who prefer “action-oriented careers” (Kolb, Boyatzis and Mainemalis, 2000). Brown *et al*., found the principal profiles of architecture students to be intuitive-thinking and intuitive-feeling types. Lawson (1993) also observed that architecture students had a tendency to adopt more intuitive approaches when engaging designs.

Singhasiri, Darasawang and Srimavin (2004) in a study of the learning styles of first-year architecture students found that majority were concrete learners- i.e., accommodators and divergers to examine if the curriculum and materials catered for these styles. While there are variances in the findings from studies of learning styles of architectural students, the general conclusion favours the fact that architectural students are concrete learners-accommodators and divergers. From the foregoing, it can be inferred that if the learning styles of architecture students tend towards concrete approaches, then any meaningful teaching and learning (be it in design courses or technical courses – in which structures is a core) that must take place must be within and tailored towards concrete approaches. So in practical terms, appropriate teaching style for structures must be responsive to the preferred learning style of architecture students, which are the diverging and accommodating learning styles.

a. Responsive Teaching Style to the Diverging Learning Style

For optimum learning to take place, a responsive teaching style to the learning style of students must creatively and carefully harmonize the key learning characteristics of the preferred learning styles. It can therefore be inferred that a responsive teaching style to the observed diverging learning style (35.59%) must be in tandem with its learning characteristics. These include Concrete Experience (CE) and Reflective Observation (RO) as dominant learning abilities, strong in imaginative ability, best at generating ideas and viewing situations from many different perspectives. Other characteristics include: interest in people, emotional, prefer to work in groups, less concerned with theorems and generalization, and approach to problem solving is not systematic. Thus by implication a responsive teaching style to the diverging learning style must include:

i. Concrete learning strategies such as model making,

ii. Group-Based learning, otherwise known as co-operative learning

iii. Project-based learning

b. Responsive Teaching Style to the Accommodating Learning Style

A responsive teaching style to the accommodating learning style must be in alignment with its key learning characteristics. These include Concrete Experience (CE) and Active Experimentation (AE) as dominant learning abilities, greatest strength is doing things, strong ability to learn from primarily "hands-on"experience, more of a risk taker- enjoy new and challenging experiences, performs well when required to react to immediate circumstances, Solves problems intuitively- tendency to act on "gut" feelings rather than on logical analysis, Prefer to work with others to get tasks done. A responsive teaching style to the accommodating learning style must therefore include:

i. Project Based Learning
ii. Group Based Learning
iii. Concrete learning strategies

5.4 The use of Information Communication Technologies (ICTs)

Findings of this study show that the degree of usage of ICTs in the teaching of architectural structures in the four universities surveyed is very low. One key finding in this section is that, none of the respondent indicated the use of any software for structural analysis and modeling. This finding becomes significant against the potential impact of ICTs. The importance of computer analysis and modelling in teaching structures lies in its potential *to fabricate and manipulate visual environments custom made to demonstrate complex structural behavior and concepts in an easy to understand visual means, which consequently develops structural understanding that culminates in structural intuition and competence in the students.* It is therefore imperative that to improve students understanding of structures, ICTs must be deliberately adopted in the teaching of structures.

5.5 The impact of Learning Inputs, Students' Profile and Learning Environment on Learning Outcome

Using categorical regression analysis, the impact of learning inputs, students profile and learning on learning outcome was examined. From the results and analysis presented in chapter four, out of a total of 19 independent variables investigated only six were significant predictors. That implies that this study was able to identify 6 predictors of learning outcomes in structures. These predictors and their implications are discussed in the subsequent section.

The variables in the order of their contributions are Student Perception of Content (B=0.307, P=0.000), level of interest (B = 0.271, , P=0.004), visual based instruction (B=0.164, P=0.03), relevance of structures to design studio (B = 0.156, P=0.033), Learning Style (Accommodator-Assimilator) (B= 0.155, P=0.001), personal profile (extrovert-introvert) (B= -0.136, P=0.002).

5.5.1 Implications of the Predictors of Learning Outcomes of Structures Instruction.

The emergence of the predictors of learning outcomes in architectural structures is significant in improving the pedagogy of architectural structures. Identifying these predictors suggests that improving learning outcomes in architectural structures is contingent on the design of instructional delivery strategies built around these predictors. A discussion of the implications of the predictors is presented in subsequent sections.

i. Students Perception of Course Content

Students' perception of course content as a predictor of learning outcomes in architectural structures implies that improvement in learning outcome would necessarily mean improvement or altering it. The findings on the students' perception of architectural structures as a course show a that majority of the students perceived structures as a course placing emphasis on calculations/analyses, and that it is relevant to their study of architecture and the design studio. However, they did not find structures to be as interesting, practical as well as easily applicable course. In fact, the study shows that a majority of the students claimed that they do not apply what they learnt in structures classes to their design studio work, thus suggesting a disconnect between what is taught in structures and the design studio work. This development obviously presents a need to rethink the pedagogy of structures in terms of curriculum content and instructional strategies.

ii. Level of Interest

As it is true for every person, students are interested in what matters to them, and so a fundamental issue is to identify what matters to architecture students. That level of interest is a predictor of learning outcome in structures implies that to improve the learning outcomes requires improving the level of interest in the course. The key issue therefore is to identify strategies that can improve students' level of interest. Strang (2014) was of the view that students interest is influenced if a course helps them reach a goal or satisfies their curiosity, they will quite naturally have a degree of interest in it. He further explained that students get interested and engaged when they see the relevance of course material to their future goals. It is therefore important to note that subject relevance to future or career goals influences students' interest. In the context of structures instruction, this implies that to improve students' interest, structures must be taught in a manner that makes it relevant to their future goal of becoming architects. This suggests that structures be taught in the context of the design studio, which is at the core of the architect's education. A few approaches have been developed in this area as documented in literature. These include the independent Lab/Studio, the total studio (1980), the second studio (1997), the structures project (2006) and the 2 plus 1 studio (2013). These were previously discussed in the literature review section of this thesis.

iii. Visual-Based Instruction

The result of the CATREG analysis showing visual based instruction as a predictor of learning outcomes implies that optimum learning in structures comes with the use of visual based instruction driven by visual thinking strategies or visuo-spatial thinking. Visuo-spatial thinking essentially employs the use of visual and spatial means in communicating knowledge. The historical perspective of visuo-spatial thinking can be seen from the work of Ferguson (1977). He observed that “thinking with pictures" was essential in the intellectual history of technological development. Pyramids, cathedrals, and rockets do not exist because of geometry, theory of structures, or thermodynamics, but because they were first a picture- literally a vision- in the minds of those who built them. Dytoc (2007) underscored the importance of visuo-spatial thinking in communicating structural knowledge by noting that architects use graphics and models for communication. He observed that graphics go a long way in clarifying structural topics. In a quest to optimize the concept of thinking with pictures, some instructors have sought to explore the potential of ICT in providing enhanced graphics to aid visuo-spatial thinking. This is characterised by computer generated graphics and visuals, which include CAD drawings, sketches, pictures, the use of structural analysis software. Vassigh (2001) also observed that one of the greatest advantages of using digital technology in teaching structures is that it enables us to fabricate visual environments custom made to demonstrate complex concepts in an easy to understand visual means. He further argued that the manipulability of these environments to emphasize or de-emphasize certain structural members further accentuates its teaching capability.

Another case in question on visuo-spatial thinking is the theory of pedagogical praxis. The theory of Pedagogical praxis suggests that new technologies make it possible to take pedagogies developed in the context of professional training-pedagogy that emphasizes participation in meaningful projects in epistemologically rich contexts – and adapting them to younger students. Pedagogical Praxis as applied to Studio mathematics, in which *design pedagogy was used as a medium in the development of mathematical understanding*, provides a veritable model for the teaching of the quantitative aspects of architectural structures that has become highly contentious (Shaffer 2005).

iv. Relevance of Structures to Design studio

The implication of relevance of Structures to design studio can provide a better insight into a possible missing gap in the quest for strategies to improve students' interest in and understanding of structures. As a predictor of learning outcomes in structures, it does imply that structures needs be taught in a manner that is relevant to the design studio. Simply put, teaching structures in the context of the design studio (or in a design studio oriented approach) has potential to stimulate students' interest and improve their understanding of structures. A survey of literature as presented earlier in this thesis identified a few approaches that attempted to teach technical courses and particular structures in the context of the design studio. Some of these approaches have been identified and discussed earlier in this thesis (see section 2.3.2).

The literature on psychology of learning also suggests that we learn best when we are motivated to learn, when we are interested in the material and when we need to know something in order to reach a desired end. We appear to learn best when we can combine theory and abstraction with perceptual experience or reality- actually seeing, touching and acting. The necessity to know and the opportunity for perceptual reinforcement that occurs in an architectural studio (or technics lab) provides a much better environment for learning the practical aspects of building technology than the lecture hall. This does not, however, negate the potential role of lectures in communicating theory and basic principles. In architecture schools, the studio represents the prime focus of the students' attention. Information necessary for the resolution of the design problem will be learned much more quickly than material taught in a more general way. Reducing the scale or complexity of a studio exercise will permit a deeper investigation of questions involving construction, ECS or structure. Similarly, establishment of specific design criteria involving technical performance will focus the students' efforts.

Also there is a theory in the learning sciences that the best way to train a teacher in a particular method is to teach that teacher using that method. If valid, this axiom would give justification for the difficulties encountered in developing and implementing new programmes that emphasize an integration of design and technics. Given the form of education experienced by most of today's design faculty (where technical subjects were taught as isolated lecture courses), the holistic approach should be difficult to implement. It might even explain some of the eagerness to retreat from accepted approaches to program integration toward more traditional methods. In addition, brain imaging research supports the view that when students find the topic applicable and are able to solve a problem themselves, they are more likely to retain and comprehend the new content (Willis, 2007). Brain-based research shows that when there are low levels of stress and learning experiences are relevant to students, they are more likely to pay attention to learning (Mendes, 2012). From the foregoing it is obvious that relevance of the learned material is fundamental to raising students' interest and motivation. The effective introduction of structural design issues in the studios provide immediate and significant improvements on the learning process of the students as explained by Cengizkan & Yalinay (2003).

Learning Style (Accommodator-Assimilator)

Having found that learning style (Accommodator-Assimilator) is a predictor of learning outcomes in architectural structures, it is imperative to devise strategies to suit the dominant learning style of the students surveyed. The study earlier showed that 35.59% of the students are divergers, 14.41% are convergers, 14.76% are assimilators, while 35.24% are accommodators. Thus, improving learning outcome in structures implies that instructional design must take cognizance of the characteristics of the "accommodators" learning style who are concrete learners and active experimenters, with greatest strength being in doing things and prefer to work with others to get things done (Kolbs Experiental Learning Theory). It is therefore imperative that optimum learning in structures must include project-based learning, group-based learning and concrete learning strategies.

Personality Profile (Extrovert-Introvert)

The result of the categorical regression analysis showing that personality profile (extrovert-introvert) is a predictor of learning outcomes in structures instructions implies that instructional design should be tailored to accommodate personality profile of students. Earlier results on the distribution of personality profiles of the students surveyed reveal that 62.4 % are extroverts while 37.6% are introverts (Table 4.17). Therefore, it thus implies that structures instruction should be designed to suit the disposition of the extroverts who are experiential learners and learn best by hands on activities. Responsive teaching strategies in structures for extroverts may therefore include group-based projects, project based learning and learning by doing.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.0 Introduction

This last and concluding chapter of this thesis is an attempt at aggregating the key findings and issues in this research and their implications. An overview of the research is presented first. Next is the summary of key findings as well as synthesis of key issues arising from the study. The implications of the study findings are also presented and discussed. The areas and opportunities for further research are highlighted before concluding remarks are made.

6.1 Overview of Research

A vast amount of literature exist on the design education component of architectural education, however very little is known about the other part which is the technical education component made up of a triad of structures, building material and methods, and environmental control systems. Specifically, much is not known about the pedagogy of structures, which is at the core of the technical component of architectural education. Structures, which is the support system of a building is inseparable from architectural form; and thus is an integral part of a building. Understanding structures is fundamental to the education of the architect. But the "content" (theory and pedagogy) and "delivery systems" (teaching methods) currently in use are unsuitable for the majority of architecture students. Architecture faculty and students struggle with a traditional engineering-based approach to structures instruction. This is increasingly proving to be ineffective.

Generally, literature suggests that there are low level of motivation of architectural students in structures classes, which has led to poor interaction, inadequate understanding, and low retention of structural principles. A greater consequence of structures is the potential impact of developing the architect's structural competence - a determinant of structural design decisions and its multiplier effect on improvements in the built environment, which further portends a threat to the architecture profession due to graduates technical unpreparedness evidenced by the waning leadership role of the architect in the construction industry. It is on this premise and the need for an appropriate understanding of the pedagogy of structures in architectural education that this study was conducted. The research activities and findings are reported in this thesis.

As previously stated, this study sought to investigate the teaching and learning of architectural structures with a view to identifying ways of improving students' interest and understanding of the course. In pursuant to this goal, Chapter One of this thesis outlined the following objectives of this study to include: (i) Assess the curriculum of architectural structures with respect to the requisite structural skills of architects (ii) Examine the teaching approaches of architectural structures and students' perception of these approaches (iii) Investigate the students' profiles (personality characteristics and learning styles of architecture students) and its influence(s) on learning outcomes in structures (iv) Assess the degree of usage of Information Communication Technology and its impact in the teaching and learning of structures (v) Investigate the influence of learning inputs, students' profiles and the learning environment on learning outcomes of structures in the selected departments of architecture in southwest, Nigeria.

Consequent upon establishing the aim and objectives of this study, Chapter Two attempted to situate this study within the broad spectrum of existing knowledge by reviewing related literature on this subject. From the literature search on the pedagogy of architectural structures, a number of concepts and theories were identified in learning sciences and architectural education generally; and specifically in technical education in architecture. The literature search established the fact that the pedagogy of architecture is composed of design and technology with architectural structures being a sub-component of technology. It further identified the two major distinct approaches to structures instruction to be the traditional engineering based approach and the alternative approaches. It was also stressed that the growing students' dissatisfaction with the traditional approaches led to the development of the alternative approaches. Thus, five different variants of the alternative approaches were identified. The underpinning concepts of the alternative approaches were identified to include visuo-spatial thinking (non verbal thinking), computer-aided learning (structural analysis software, modeling and simulation) and design pedagogy (experiential learning). Identification of these three concepts provided a rubric for this study.

In an attempt to establish direction, focus and limit for this study from the array of concepts and theories identified, it was imperative to develop a conceptual framework that covers both theoretical and conceptual issues relevant to the study. Chapter Three dealt with a presentation of a framework from the existing and relevant supporting concepts. Developing this framework provided the basis for the review of literature, data collection, analysis and discussion of the results and implication of findings.

Further to establishing the framework for data collection, analysis and discussion of results and findings, it was imperative to set out the methods used in the research design, data collection, presentation, processing, analysis and interpretation of results. It was noted that that both qualitative and quantitative research strategies were used in this study, and that the units of data collection and analysis were students and faculty members in the four department of architecture. The chapter also identified the questionnaire interview guide and observation schedule as the principal data collection instruments used in this study. Both descriptive and inferential statistics as well as content analyses tools were used in the analysis of data collected from the fieldwork and literature search. Chapter Four was a presentation of the findings of this study (objective by objective). The interpretation of the results and findings and their implications were presented in Chapter Five, was the discussion of the findings of the study. The last Chapter was the presentation of summary of key findings, synthesis of key issues arising from the study and their implications, contributing to knowledge areas of further research and final conclusions.

6.2 Summary of Key Findings

1. The content of the NUC curriculum appears broad (not detailed and specific) thus leaving room for subjective interpretation of the benchmark by the different schools. It was observed that comparing the 5 semesters (a total of 10 units) of FUTA and UNILAG to the 6 semesters (17 units) and 7 semesters (18 units) for OAU and CU respectively clearly shows that the curricula of the FUTA and UNILAG is characterised by brevity while those of OAU and CU are characterised by depth and thoroughness of scope.

2. The sequence of the curricula was found to be the same across the four schools surveyed and more importantly identical to the classical sequence of presenting physics, statics, and strength of materials, analysis and “design” which though represents a logical progression of information has been divorced from involvement with the total process of architectural design.
3. The emphasis of the curricula was observed to be divergent across the four universities. FUTA and UNILAG curricula appeared to be inclined more towards the architecture polarity (theory) while those of CU and OAU appeared to be inclined more towards the engineering polarity (calculation) at least to some extent.

4. The relative weight of the structures credit units in the overall graduation benchmark for architecture was observed to be 6.85% for the NUC-BMAS. Whereas CU and OAU have similar weights of 6.49% and 7.69%, FUTA and UNILAG were observed to have similar weights of 4.23% and 4.69% respectively.

5. The learning outcomes calibrated on two scales of structural literacy (acquisition of structural knowledge) measured by structural knowledge index (SKI) using test scores and structural competence (ability to use and apply structural knowledge to solve design problems) measured by structural intuition index (SII) using students application of knowledge gained in structures class to design studio had mean scores of 0.790 and 0.716, respectively. It was observed that the SKI was higher than the SII in each of the four universities surveyed.

6. The majority (62.4%) of the architecture students surveyed are extroverts (who focus on external reality and direct their attention toward people and objects and are experiential learners, learn best by hands-on exercises and activities), while 37.6% are introverts.
7. Most (72.8%) of architecture students sampled are sensers (*concrete learners*-rely on one or more of the five senses to interprete facts or events), while 27.2% are intuitors (*abstract learners* -tuned to conceptual and theoretical issues).
8. The learning style profile of the students was observed to be majorly Divergers (35.59%) and Accommodators (35.24%) characterised by Concerete Experience (CE) as contrasted to Convergers (14.41%) and Assimilators (14.76%), characterised by Abstract Conceptualization (AC).
9. From the nine teaching approaches evaluated, lectures were found to be the most predominant teaching approaches, followed by tutorials. Group-Based Project ranked

third, while Study of structural failures, study of historical structures, the usage of graphics (sketches and pictures) ranked 4^{th}, 5^{th} and 6^{th}. Ranking least on it 7^{th}, 8^{th} and 9^{th} positions were the use of models, case studies from practice and laboratory tests and investigations .

10. The majority of the students were of the opinion that structures places emphasis on calculations/analyses, but they agree that it is relevant to their study of architecture (and the design studio) and did not find it to be as interesting, practical and easily applicable.
11. Most of the students also claimed that they do not apply what they learnt in structures to their design studio works, thus suggesting a disconnect between what is taught in structures and the architectural design studio.
12. Around 43% of the students would rather not choose structures if made optional, while 57% would choose it. This suggests that there is relatively low level of interest in architectural structures among the students sampled.
13. The degree of usage of ICTs in the teaching of structures across the four universities surveyed is very low. Notably, none of the respondents indicated the use of any software for structural analysis and modeling.
14. The study identified 6 predictors of learning outcomes in structures instructions Student Perception of Content (B=0.307, P=0.000) emerged as the strongest. This is followed by level of interest (B = 0.271, , P=0.004), visual based instruction (B=0.164, P=0.03), relevance of structures to design studio (B = 0.156, P=0.033), Learning Style (Accommodator-Assimilator) (B= 0.155, P=0.001) and personal profile (extrovert-introvert) (B= -0.136, P=0.002).

6.3 Implications of Study Findings

This section attempts to highlight the possible implications of the findings of this study. The implications for education and the practice of architecture are discussed. First, one of the key challenges of the pedagogy of architectural structures is a disconnected curriculum. The sequence of the curriculum was found to be the same across the four universities surveyed and more importantly identical to the classical sequence of presenting physics, statics, and strength of materials, analysis and "design". Black and Duff (1994) and Hedges (2014) observed that though the classical sequence represents a logical progression of information, it is divorced from involvement with the total process of architectural design and independent and disconnected from its purpose of complementing the architectural design process. This sequence has resulted in producing architectural graduates who have no understanding of the basic principles involved, cannot apply them, nor retain for a significant period after graduation the basic core of material encountered, (see Richard Bender, 1976 cited by Black and Duff (1994). It is thus obvious that the observed trend of the sequence of structures curricula across the four universities that is typical of the classical structures sequence suggests a need for a rethink of ways to restructure the curricula for better results in learning outcomes.

The emphasis of the curricula observed to be divergent across the four universities with FUTA and UNILAG curricula inclined towards the architecture polarity (theory), while those of CU and OAU appear to be inclined towards the engineering polarity (calculation). It is therefore evident that there is a divide as it relates to the appropriate structures pedagogy. The impact of this divide was succinctly captured by Black and Duff (1994) as previously discussed. Muttoni (2006) corroborates this view by noting that knowing how to calculate and dimension does not necessarily mean that one understands the functioning, or knows how to design a structure. In view of the observed shortcomings in the sequence and emphasis of the content of the curricula, a rethink and a review of the curricula have become inevitable in attempt to improve students' interest and understanding of architectural structures.

Regarding personality characteristics, the study found that a majority (62.4%) of the architecture students sampled are extroverts (who focus on external reality and direct their attention toward people and objects and are experiential learners, learn best by hands-on exercises and activities). Hence teaching strategies that would improve their learning outcomes should include the following: group based work, field trips/site visit, project based learning, learning by doing, problem-based learning and model making.

The study also found that a majority (72.8%) of the students are sensers (*concrete learners-who* rely on one or more of the five senses to interprete facts or events*)* as contrasted with intuitors (abstract/conceptual learners) who are more tuned to abstract and theoretical issues. Therefore, it is necessary that the corresponding teaching style(s) should adopt concrete approaches that promote hands-on experience. This can be achieved by the use of models (physical or digital), experiments and facts. This finding has become very relevant to the study of architectural structures, noting that significant portions of the curriculum deal with abstract-conceptual and theoretical- issues.

On the learning style profile, the students were found to be majorly divergers (35.59%) and accommodators (35.24%) characterised by concerete experience (CE) as contrasted to convergers (14.41%) and assimilators (14.76%), who are known for Abstract Conceptualization (AC). The importance of this finding is that architecture students are concrete learners with a unique thinking and communication pattern.

In view of the fact that Diverger- has CE and RO as dominant learning abilities, strong in imaginative ability, best at generating ideas and viewing (concrete) situations from many different perspectives, interested in people, emotional, broad cultural interests, prefer to work in groups, and are less concerned with theorems and generalizations with systematic approach to problem solving , it is therefore important to adopt instructional strategies involving: group-based work, project-based learning (learning by doing) in meeting their instructional needs.

Accommodator- has CE and AE as dominant learning abilities, greatest strength is doing things, strong ability to learn from primarily “hands-on” experience, are more of a risk taker- enjoy new and challenging experiences, performs well when required to react to immediate circumstances, solves problems intuitively- tendency to act on “gut” feelings rather than on logical analysis, and prefer to work with others to get tasks done. Thus, appropriate instructional strategies must employ project-based learning, and group-based learning on meeting the needs of the cohort of students in architecture.

The findings also show that from the nine teaching approaches evaluated, lectures emerged as the most predominant teaching approaches, followed by tutorials. Group-based project ranked third, while study of structural failures, study of historical structures, and usage of graphics (sketches and pictures) ranked 4th, 5th and 6th. Ranking least in the 7th, 8th and 9th positions respectively. In view of this were the use of models, case studies from practice and laboratory tests and investigation. There is the need for faculty to embrace the use of models and case studies (concrete learning strategies) particularly because of their potentials improving the learning outcome in architecture students who are concrete learners

The majority of the students perceived that structures placed emphasis on calculations/analyses. They also agree that it is relevant to their study of architecture (and the design studio) but were not finding it to be interesting, practical and easily applicable. This suggests that there is a need for structures pedagogy to place less emphasis on structural analyses but with more emphasis on structural behaviour. This is consistent with Allen's (1992) submission, that we (lecturers) spend far too much time teaching calculations, which are the least important thing about structural design. It is much more important for students to learn real-world structural concepts and develop structural insight. It is therefore imperative that structures pedagogy should be designed to develop structural intuition in the student through emphasis on structural behaviour of structural elements.

Further, most of the students claimed that they do not apply what they learnt in structures to their design studio works, suggesting a disconnect between what is taught in structures classes and the design studio (whereas structures is supposed to furnish and complement the design studio). This implies that architectural structures in the four universities surveyed appear not to be achieving the expected objective. Addressing this shortcoming would necessitate that structures pedagogy and curriculum be made relevant to the design studio. In other words, structures should be taught in a design studio context. A couple of instructional models have been developed in this regard, these inculde the total studio (Levy, 1980), the second studio/technology/technical studio (Allen, 1997), the structures project (Chiuini, 2006) and The 2 plus 1 studio (Schoenefeldt, 2013) previously stated in this thesis.

Another key finding in this study is that the degree of usage of ICTs in the teaching of structures in the four universities surveyed is very low as none of the respondents indicated the use of any software for structural analysis and modeling in teaching architectural structures. The potential benefit of digital technologies in structures instruction was captured by Black and Duff (1994) who noted that *it enables us to fabricate visual environments custom made to demonstrate complex concepts in an easy to understand visual means*. In view of this, adoption of digital technology for structures instruction becomes imperative. It also evident from this study that the strongest predictors of learning outcome in structures instructions in the order of their contributions are Student Perception of Content (B=0.307, P=0.000), level of interest (B = 0.271, , P=0.004), visual based instruction (B=0.164, P=0.03), relevance of structures to design studio (B = 0.156, P=0.033), Learning Style (Accommodator-Assimilator) (B= 0.155, P=0.001), personal profile (extrovert-introvert) (B= -0.136, P=0.002).

From the foregoing, it is evident that the learning process (constituting of the learning styles and personality characteristics) of architecture students in the universities surveyed which is consistent with previous studies by Demirkan, and Demirbas, (2007) is driven by a unique thinking and communication pattern or skill. Based on the findings of this study that architecture students surveyed are concrete learners, the thinking skill of architecture students can be described as visuo-spatial, while their communication is essentially visual communication. It is therefore imperative that the acquisition of any knowledge in architectural education must take cognisance of the architecture students' visuo-spatial thinking and visual communication skill. The implication of this is that structures pedagogy in architecture is confronted with a dilemma of Visuo-spatial thinking (his thinking mode) versus mathematical thinking (the prevalent mode of structures) and visual communication (his communication mode) versus numeric communication. This development was aptly captured more than 50 years ago by Mario Salvadori, the acclaimed structural engineer and educator, who argued that the architect and engineer must have a general vocabulary if they are to work together productively.

6.4 Contribution To Knowledge

While this study explored the pedagogy of architectural structures on a broad scale, it has contributed to knowledge in the following specific areas:

i. It has identified useful parameters in developing a teaching model responsive to the personal characteristics and learning styles of architectural students.
ii. It has provided insight into the relationships, interactions and impact of pedagogy, content and technology (computer-aided instruction) on teaching of structures and technology education.
iii. The study has identified the predictors of learning outcomes in architectural structures (factors that contribute most).

6.5 Areas for further Study

This study is probably a pioneering study on the pedagogy of architectural structures in Nigeria, however it covered only four department of Architecture Universities in South-west, Nigeria. Therefore, the following areas are recommended for further research:

i. Future studies on this subject to cover the other Departments of Architecture in Nigerian Universities for the purpose of identifying trends and patterns.
ii. Detailed study on perception and performance of a particular group of students in architectural structures over a period of three to four years, to check for fluidity.
iii. Assessment techniques in architectural structures viz-a-viz design studio so as to identify possible convergent or divergent points.
iv. Impact of curricula design on learning outcome in of architectural structures.

6.6 Concluding Remarks

The aim of this study was to investigate the teaching and learning of architectural structures in four universities in Southwest, Nigeria, with a view to identifying ways of improving students' interest and understanding of the course. With respect to the aim of the study, the following are the conclusions, which have been drawn from the findings of this study.

The first objective was to assess the curriculum of architectural structures in four selected universities in Southwest, Nigeria. The result shows that the current traditional sequence of the structures curriculum was isolated from the architectural design process and independent and disconnected from its purpose of complementing the architectural design process. This sequence has resulted in producing architectural graduates who have no understanding of the basic principles involved, cannot apply them, nor retain for a significant period after graduation the basic core of material encountered (Black and Duff (1994). It is thus obvious from the study that there is an imminent need for a curriculum review and a design studio oriented approach to teaching structures.

The second objective was to examine the approaches to the teaching of architectural structures and student's perception of these approaches in the study area. It was found that the teaching approaches placed more emphasis on structural analyses that promote structural literacy than on structural behaviour, which engenders structural competence identified as the desired learning outcome. The study implies that the adoption of visuo-spatial thinking and visual communication strategies in contrast to mathematical thinking and numeric communication strategies currently in use in teaching structures in the study area is critical to improving and sustaining architecture students' interest in and understanding of structures as a course.

The third objective was to investigate the students' profiles (personality characteristics and learning styles of architecture students) and their influences on learning outcomes in architectural structures in the selected universities. The findings on the personality profile of the students indicate that majority (62.4%) are extroverts (who focus on external reality and direct their attention toward people and objects and are experiential learners, learn best by hands-on exercises and activities). Also 72.8% of the students sampled are sensers (*concrete learners*-rely on one or more of the five senses to interprete facts or events*)*. The learning style profile of the students was observed to be majorly Divergers (35.59%) and Accommodators (35.24%) characterised by Concerete Experience (CE) as contrasted to Convergers (14.41%) and Assimilators (14.76%), characterised by Abstract Conceptualization (AC). The study findings therefore imply that instructional delivery strategy in structures must take cognisance of the identified learning styles and personality preferences of the students characterized by experiential learning and concrete approaches that promote hands-on experience.

The fourth objective was to assess the degree of usage of Information and Communication Technologies and its impact in the teaching and learning of architectural structures in the four universities sampled. The study finings showed that the use of Information and Communication Technologies (ICTs) in the teaching and learning of structures was low in the four universities sampled. Adoption of digital technologies therefore becomes imperative as it enables the fabrication and simulation of visual environment and consequently enhances better understanding of structural behaviour. The fifth and last objective was to investigate the impact of learning inputs, students' profiles and the learning environment on learning outcomes of structures in the selected universities. The regression model revealed that students' perception of curriculum content (β=0.307), level of interest (β =0.271), visual based instruction (β =0.164), relevance of structures to design studio (β =0.156), learning style (β =0.155) and personality characteristics (β =0.136) emerged as the strongest predictors of the learning outcomes in structures. This implies that optimum learning in structures is contingent on an instructional strategy built around these six predictors.

6.7 Recommendations

In the light of the implications of the study findings and the concluding remarks, presented below are the recommendations that stemmed out of this study:

i. The curriculum of architectural structures should be reviewed with emphasis on a design studio-oriented approach i.e. structures curriculum should be design studio relevant.
ii. The content of the curriculum should be reviewed to contain only what is relevant to the design studio and eliminate unnecessary engineering theories.
iii. The sequence of the curriculum should be reviewed from the classical sequence that focus on local behaviour to a learning on demand approach that focus on global behaviour
iv. Visuo-spatial thinking and visual communication strategies in contrast to mathematical thinking and numeric communication strategies should be adopted in the teaching of structures to improve and sustain students' interest in and understanding of structures as a course.
v. The study of structures must place emphasis on structural behaviour, which promotes structural competence than on structural analysis that results in structural literacy.
vi. Development of structural competence, ability to creatively use the knowledge of structures as a design tool in the design process should be the prime objective of the study of structures.
vii. Teaching style(s) should be designed to accommodate the identified learning styles and personality preferences of the students characterized by experiential learning and concrete approaches that promote hands-on experience. This can be achieved by project-based learning (learning by doing), problem-based learning, the use of models, group-based work and site visit.

viii. Digital technologies such as use of audio-visuals and structural analysis software should be employed in the teaching process to enable fabrication and simulation of visual environment and consequently enhance better understanding of structural behaviour.

ix. The instructional delivery strategy of architectural structures should be designed around the six identified predictors of learning outcome to ensure optimum learning. These include Student Perception of Content, level of interest, visual based instruction, relevance of structures to design studio, Learning Style (Accommodator-Assimilator), and personality profile (extrovert-introvert).

REFERENCES

Adejimi, A. (2007). Comparing Traditional Synchronous Teaching with E-Learning in the Teaching of Architecture at Olabisi Onobanjo University. *Journal of Environmental Technology*, **1(1/2):** 105-109.

Adeyemi, E.A. (2012). *In the making of an architect: the Zaria experience*. Ota: Covenant University Press.

Aderounmu, A. (2013). The Design Studio in Selected Schools of Architecture in South-West Nigeria: A Case Study of Pedagogy, Culture and Environment. Unpublished PhD Thesis Submitted to the School of Postgraduate Studies, Covenant University, Ota, Nigeria.

Allen, E. (1997). Second Studio: A Model for Technical Teaching. *Journal of Architectural Education*, **51(2):** 92-95.

Allen, E. (1992). Polarities: Teaching Structures. *Connector*, **1(1):** 1.

Amato, A; Thilakaratne, R; Henri, J; & Trinidad, S.G. (2004). *Technology Enhanced Construction Technology Teaching*. Paper presented at The 4th IEEE International Conference on Advanced Learning Technologies in Joensuu, Finland, 30 August-1 September, 2004. Available Online: http://hdl.handle.net/10722/47023. Retrieved 4th July 2012.

Banham, R. (1984). *The Architecture of the Well-Tempered Environment* (2nd ed.). Chicago: University of Chicago Press.

Barry, B. and Yadav, A. (2007). *The Case Method: Using Case-Based Instruction To Increase Ethical Understanding in Engineering Courses*. Paper presented at the 114th Annual American Society of Engineering Education Conference and Exposition in Honolulu, United States, 24 -27 June, 2007. Available Online at http://docs.lib.purdue.edu/enegs/1/. [Accessed on 15th March 2013]

Belcher, J. W. (2001). Studio Physics at MIT. In MIT Physics Annual. Available online from: http://evangelion.mit.edu/802teal3d/visualizations/resources/ PhysicsNewsLetter.pdf. [Accessed 11 June, 2012]

Benbasat, I. (1984). An Analysis of Research Methodologies. In F.W, McFarlan (Ed.) *The Information Systems Research Challenge* (Pp. 47-85). Boston, MA: Harvard Business School Press.

Benbasat, I., Goldstein, D,K, and Mead, M. (1987). The Case Research Strategy in Studies of Information Systems. *MIS Quarterly*, **11(3):** 369-386.

Bender, R. (1976, June). The teaching of structural design. Association of Collegiate Schools of Architecture [ACSA Memo]. Reprinted and cited by Black, R. G., & Duff, S. (1994). A model for teaching structures: Finite element analysis in architecture education. *Journal of Architecture Education*, **48(1):** 38-55.

Beichner, R., Bernold, L., Burniston, E., Dail, P., Felder, R., Gastineau, J., Gjertsen, M., & Risley, J. (1999, July 1). Case study of the physics component of an integrated curriculum. *American Journal of Physics.*, **67(7):** 16-24. Retrieved October 23, 2014, from http://dx.doi.org/10.1119/1.19075

Billington, D.P. (1985). *The Tower and the Bridge*. (1st ed.). Princeton, NJ: Princeton University Press.

Black, G. (1993) Studio Teaching Polarities: Teachers' Responses. *Connector: A Forum for Teachers of Technology in Schools of Architecture.* **2(1):** 2-4.

Black, G. and Duff, S. (1994). A Model for Teaching Structures: Finite Element Analysis in Architectural Education. *Journal of Architectural Education*, **48(1):** 38-55.

Bonwell, C., & Eison, J. (1991). Active learning: Creating excitement in the classroom (ASHE-ERIC Higher Education Report No. 1). Washington, DC: George Washington University. Available online at http://www.ed.gov/databases/ERIC_Digests/ed340272.html [Accessed on March 15, 2012]

Bruneau, M, El-Bahey, S, Fujikura, S & Keller, D. (2011). Structural Fuses and Concrete-Filled Steel Shapes for Seismic and Multi-Hazard Resistant Design. *Bulletin of the New Zealand Society for Earthquake Engineering*, **44(1):** 45-52.

Camarata, K, Gross, M.D, &Yi-Luen Do, E. (2002) Physical Computing: A Design Studio that Bridges Art, Science, and Engineering. Paper presented at The Fifth International Conference of the Learning Science in Seattle, United States. 23-26 October, pp. 520-521.

Cengizkan, A. & Yalinay, S. (2003). *Arch 301& Arch 302 Architectural Design Studio*, Course in Middle East Technical University, Department of Architecture, Ankara, Turkey.

Charleson, A.W. (1995). Seismic Design within Architectural Education. In Proceedings of Pacific Conference on Earthquake Engineering, Melbourne, pp. 43-48 and reprinted in *Bulletin of the New Zealand National Society for Earthquake Engineering,* **30(1):** 46-50.

Chiuini, M. (2006). *Less Is More: A Design-oriented Approach to Teaching Structures in Architecture*. In Oakley, D.J. & Smith, R.E.(Eds.), Proceedings of the 2006 Building Technology Educators' Symposium (pp. 205-211). Idaho: The Building Technology Educator's Society, Inc.

Covenant University [CU]. (2013). Departmental handbook, Department of Architecture.

Diamond, S., & Webb, B. (1992). Fostering Technology in Design. *Connector: A Forum for Teachers of Technology in Schools of Architecture.* **1(1):** 4-5.

Dawson, C. (2002). *Practical research methods: A user-friendly guide to mastering research techniques and projects.* London: Howtobooks.

Demirkan, H., & Demirbas, O.O. (2008). Focus on the Learning Styles of Freshman Design Students. *Design Studies* **29(3):** 254-266.

Demirkan, H., & Demirbas, O.O. (2007). Learning Styles of Design Student and the Relationship of Academic Performance and Gender in Design Education. *Learning and Instruction.* **17:** 345-359.

Dieste, E., & Candela, F. (2009). Evolution and Trends in Design, Analysis and Construction of Shell and Spatial Structures. In *Proceedings of the International Association for Shell and Spatial Structures (IASS) Symposium,* Valencia 2009.

Dollar, A. and Steif, P.S. (2008). An Interactive, Cognitively Informed, Web-Based Statics Course. *International Journal of Engineering Education.* **24(6):**1229-1241.

Dori, Y. J. and Belcher, J. W. (2005). How Does Technology-Enabled Active Learning Affect Undergraduate Students' Understanding of Electromagnetism Concepts? *The Journal of The Learning Sciences,* **14(2):** 243–279.

Dori, Y. J., Hult, E., Breslow, L. & Belcher, J.W.(2007). How Much Have They Retained? Making Unseen Concepts Seen in a Freshman Electromagnetism Course at MIT. Journal of Science Education and Technology (2007). *Journal of Science Education and Technology,* **16(4):** 299-323.

Dytoc, B.C. (2008). Effective Graphics in Structures Class: Integrating Structures into Architecture. *Journal of Architecture, Landscape Architecture and Designed Environment. University of the Philippines College of Architecture.* **1(3):** 51-58.

Federal University of Technology Akure [FUTA]. Departmental handbook, Department of Architecture.

Felder, R.M. & Brent, R. (2004). *"The ABCs of Engineering Education: ABET, Bloom's Taxonomy, Cooperative Learning, and So On.*" Paper presented the 2004 American Society for Engineering Education Annual Conference & Exposition. Retrieved from http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/ASEE04(ABCs).pdf on September 30, 2014.

Ferguson, S.E. (1977). The Mind's Eye: Nonverbal Thought in Technology. *Science,* **197(4306):** 827-836.

Forsythe, P. (2009). The Construction Game – Using Physical Model Making to Simulate Realism in Construction Education. *Journal for Education in the Built Environment,* **4(1):** 57-74.

Fletcher, S., J. Potts & R. Ballinger (2008). The pedagogy of integrated coastal management. *The Geographical Journal.* **174(4):** 374-386.

Fowler, B., & Wilson, F. (2004). Women Architects and Their Discontents. *Sociology,* **38(1):** 101-119.

Galanes, C. and Hamblen, K. A.(1991**)** Instructional Options for Aesthetics: Exploring Possibilities. *Journal of Art Education,* **44(6):** 12-24.

Galliers, R. (1991.) Choosing appropriate information systems research approaches: A revised taxonomy. R. Galliers, (Ed.) *Information Systems Research: Issues, Methods and Practical Guidelines* (pp 144-162). Oxford: Blackwell.

Garvin, D.A. (2003). Making the case: Professional education for the world of practice. *Harvard Magazine*, **106:** 56-65.

Gelernter, M. (1988). Reconciling Lectures and Studio. *Journal of Architectural Education, Winter 1988.*

Germain, C. S (2002) *Historical Perspective: Major Theories Modeled in The 4MAT System for Teaching Learning and Leadership*.Wauconda: About Learning Inc.

Ghozi, M. (2011). Evolutionary Parallel SAP2000 for Truss Structure Optimization. *International Journal of Academic Research*. **3(2):** 1140-1145.

Gill J. and Johnson P. (1997) *Research Methods for Managers*, (2nd ed.). London: Paul Chapman Publishing.

Glatthorn, A., Boschee, F., Whitehead, M., & Boschee, B. (2012). *Curriculum leadership: Strategies for development and implementation*. (3rd ed.). California: SAGE Publications Inc.

Gordon, J.E. (2003). *Structures or Why Things Don't Fall Down* (2nd ed.). pp 17-18. Boston: Da Cappo Press.

Hake, R. (1998). Interactive-engagement versus traditional methods: a six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, **16:** 64–74.

Hake, R. (2007). Six Lessons From The Physics Education Reform Effort. *Latin America Journal of Physics Education*, **1(1):** 24-31.

Haglund, B. (1993) Studio Teaching Polarities: Teachers' Responses. *Connector: A Forum for Teachers of Technology in Schools of Architecture.* **2(1):** 2-4.

Hamiti, M., & Reka, B. (2012). Teaching with Technology. *Procedia – Social and Behavioural Sciences*. **46:** 1171-1176.

Harris, C.M. (2006). *Dictionary of Architecture and Construction*. (4th ed.). New York: McGraw Hill.

Hedges, K.E. (2014). *Introduction to Architectural Structures: Lessons Learned from Parti Pris Pedagogy*. Paper presented at the 121st American Society for Engineering Education Annual Conference & Exposition, in Indianapolis, June 15-18, 2014.

Hein, M.F., & Williams, S. (1990). *Rethinking The Structures Curriculum*. Paper presented at Associated Schools of Construction 26th Annual Conference, held at Clemson University, South Carolina. April 8-10, 1990. pp 51-58.

Hong, P. (2011). *Sweetening Structural Principles for Architectural Students.* Paper presented at the 2011 American Society of Engineering Education Annual Conference and Exposition held at the Vancouver Convention & Exhibition Center, 26-29 June 2011.

Hurtt, L.S., Wieldemann, G. and Gardner, A.E. (1995). Comprehensive Design Studio: University of Maryland. *Connector: A Forum for Teachers of Technology in Schools of Architecture.* **4(2):** 1-2.

Hsu, C.H.C. (1999). Learning Styles of Hospitality Students. *International Journal of Hospitality Management*, **18(1):** 17-30.

Kaplan, B., & Duchon, D. (1988). Combining Qualitative and Quantitative Methods in Information Systems Research: A Case Study. *MIS Quarterly*. **11(3):** 369-386.

Kayes, D.C. (2002). Experiential learning and its critics: Preserving the role of experience in management learning and education. *Academy of Management Learning & Education*, **1(2):** 137-149.

Koehler, M.J. & Mishra, P. (2008). Introducing TPCK. In AACTE Committee on Innovation and Technology (Ed.), The handbook of technological pedagogical content knowledge (TPCK) for educators (pp. 3-29). New York, NY: Routledge.

Kolb, A. Y. & Kolb, D. A. (2005a). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning and Education.* **4(2):** 193-212

Kolb, A. Y. & Kolb, D. A. (2005b). The Kolb learning style inventory—version 3.1: 2005 Technical Specifications. Boston, MA: Hay Resources Direct.

Kolb, D. A., Boyatzis, R.E. & Mainemelis, C. (2000) Experiential Learning Theory: Previous Research and New Directions. In R. J. Sternberg and L. F. Zhang (Eds.), *Perspectives on cognitive, learning, and thinking styles.* NJ: Lawrence Erlbaum, 2000.

Kothari, C.R., (2004), *Research Methodology- Methods and Techniques*. New Delhi: New Age International Publishers.

Kvan, T and Yunyan, J. (2005). Students' Learning Styles and Their Correletion with Performance in Architecture Design Studio. *Design Studies*, **26(1):** 19-34.

Kruskal, W. (1984). Concepts of Relative Importance. *Questro,* **8(1):** 39-45.

Kumar, R. (2005) Research Methodology A Step-by-step Guide for Beginners, (2nd ed.). Australia: Pearson Education.

Larrick, T. (1949). Objectives in Teaching Sturctures. *Journal of Architecture Education* **14:** 15-18.

Lawson, B. (1993). Parallel lines of thought. *Languages of Design*, **1(4):** 357-366.

LeFrancois, G. (2000). Theories of Human Learning: What the old man said. (4th ed.). University of Alberta. Alberta: Wadsworth.

Levin, D. M. (1988). The opening of vision: Nihilism and the postmodern situation. London: Routledge.

Levy, A (1980). Total Studio. *Technics and Design Education.* **34(2):** 29-32.

LoPiccolo, O.S. (2011). *Implementing Student-Building Physical Models: Advanced Framing and 3'' Cube to Improve Spatial Reasoning Ability Among Freshmen Architectural Engineering and Construction Management Students*. Paper presented at the 2011 American Society of Engineering Education Annual Conference and Exposition held at the Vancouver Convention & Exhibition Center, 26-29 June 2011.

Lowerison, G., Sclater, J., Schmid, R. F., & Abrami, P. C. (2006). Student Perceived Effectiveness of Computer Technology Use in Post-secondary Classrooms. *Computer and Education*, **47:** 465-489.

Lucko, G., Heisman, E. A. & Gonzalez, E. C. (2010). Student-Centered Learning Environment for Disaster-Mitigating Engineering Design and Deployment in Developing regions. *International Journal for Science Learning in Engineering*. **5(1):** 189-209

Martini, K. (2006). A New Kind of Software for Teaching Structural Behaviour and Design. In Proceedings of the 2006 Building Technology Educators' Symposium. Pp279-288. Available online at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.113.5612&rep=rep1&type=pdf [Accessed on July 18, 2013]

MacCallum, C. and Hanna, R. (1996). *Deflect: A Computer Aided Learning Package For Teaching Structural Design.* In Proceedings of Education and Research in Computer Aided Architectural Design in Europe (eCAADe 1996) Conference. pp 253-262.

MacNamara, S. (2011). *The Use of Historical Precedents in Teaching Structural Analysis to Architecture Students*. Paper presented at the 2011 American Society of Engineering Education Annual Conference and Exposition held at the Vancouver Convention & Exhibition Center, 26-29 June 2011.

Mendes, J. (2012) Five Ways to Create an Optimal Learning Environment for Students. Downloaded from http://www.readinghorizons.com/blog/post/2012/06/07/increase-student-attention-anticipation-interest-during-a-lesson.aspx on 14th June, 2014.

Mergendoller, J.R; Maxwell, N.L; and Bellismo, Y. (2006). The Effectiveness of Problem-Based Instruction: A Comparative Study of Instructional Methods and Student Characteristics. *Interdisciplinary Journal of Problem-Based Learning*. **1(5):** 49-69.

Mishra, P., & Koehler, M.J. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teacher knowledge. *Teachers College Record*, **108(6):** 1017-1054.

Michener, H. A., DeLamater, J. D. & Myers, D. J. (2004), *Social Psychology* (5th ed.). Australia: Thompson Wadsworth.

Moore A. H, Fowler S.B & Watson C.E. (2007) Active Learning and Technology: Designing Changes for Faculty, Students and Institutions, *Educause Review*, **42(5):** 42-61

Morris, E.T, Black, G.R, & Tobriner, S.O. (1995). Report on the Application of Finite Element Analysis to Historic Structures: Westminster Hall, London. *Journal of the Society of Architecture Historians*, **54(3):** 336-347.

Muttoni, A. (2006) *The Art of Structures*. Oxford: Routledge, Taylor & Francis Group.

Newland, P., Powell, J. A., & Creed, C. (1987). Understanding architectural designers' selective information handling. *Design Studies*, **8(1):** 2-16.

National Universities Commission Benchmark Minimum Academic Standards(NUC-BMAS) For Undergraduate Programmes in Nigerian Universities for Environmental Sciences, April 2007.

Obafemi Awolowo University, Ile-Ife. [OAU, Ile-Ife]. Departmental handbook, Department of Architecture.

O'Brien, T. P., Bernold, L. E., and Akroyd. D. (1998). Myers-Briggs Type Indicator and Academic Achievement in Engineering Education. *International Journal of Engineering Education*, **14(5):** 311-315.

Ochsendorf, J.A. (2005). Sustainable Engineering: The Future of Structural Design. In Proceedings of Structures Congress 2005: Metropolis & Beyond. Reston: ASCE. pp. 1-8.

Ochshorn, J. (1990). "Separating Science from Architecture: Why Technology is Taught Outside the Design Studio," *The Architecture of the In-Between, pp 453-460*: In Proceedings of the 78th Annual Meeting of the ACSA, 1990, San Francisco, CA, March 17-20, 1990.

Oliver, P. (2004). *Writing Your Thesis*. London: SAGE Publications Limited

O'Leary, Z. (2004). *The Essential Guide To Doing Research*. California: SAGE Publication Inc.

Onouye, B. and Kane, K. (2002). *Statics and Strength of Materials for Architecture and Building Construction* (2nd ed.). New Jersey: Prentice Hall.

Place, J.W. (2007). *Architectural Structures*. New York: John Wiley & Sons.

Plesums, G. (1974). On Teaching Structure Systems. *Journal of Architecture Education.* **27(4):** 68-77.

Polkinghorne, D.E. (1983). *Methodology for the Human Sciences: Systems of Inquiry.* Albany, NY: State University of New York Press.

Potangaroa, R. & Murphy, C. (2004). Talk to me! The communicating styles of architectural students. In Proceedings of the 38th International Conference of Architectural Science Association (pp. 319 – 323). Launceston, Tasmania.

Pye, D. (1964). *The Nature of Design.* New York: Reinhold.

Rao, V.S & Narayana, P.S. (1998). *Organization Theory and Behavior.* Delhi: Konark Publishing Company.

Rennie, L.J. (1998). Guest editorial: Improving the interpretation and reporting of quantitative research. *Journal of Research in Science Teaching*, **35:** 237–248.

Remenyi, D., Williams, B., Money, A. & Swartz, E. (1998). *Doing research in business and management, an introduction to process and method.* London: Sage Publications.

Ruthven, K.; Hennessy, S. & Deaney, R. (2008). Construction of dynamic geometry: A Study of the Interpretative Flexibility of Education Software in Classroom Practice. *Computer & Education*, **51:** 297-317.

Salonga, J. (2007). Parallels in Teaching Visual Arts and Engineering Design. Retrieved from https://www.asee.org/documents/sections/st-lawrence/2007/Salonga-2007-Parallels-in-Teaching-Visual-Arts-and-Engineering-Design.pdf on February 26, 2013.

Salvadori, M. (1958) Teaching Structures to Architects. *Journal of Architecture Education.* **13(1):** 5-8.

Sattineni, A. (2008). Paving New Roads To Knowledge: An Experiment to Enhance Construction Education. *Journal of College Teaching & Learning.* **5(4):** 39-48.

Savery, J.R & Duffy, T.M (1995). Problem Based Learning: An Instructional Model and Its Constructivist Framework. Educational Technology, **35(5):** 31-38.

Senior, B.A (1998). Infusing Practical Components into Construction Education. *Journal of Construction Education.* **3(2):** 92-101.

Serasin, L. C. (1999). *Learning Style Perspectives: Impact in the classroom*. Madison, WI: Atwood Publishing.

Setareh, M., Bacim, F., Jones, B.D., Polys, N.F., Geng, T., & Orsa, B. (2011). Integrating Web-based Visualization with Structural System Understanding to improve the Technical Education of Architects. *Journal of Online Engineering Education.* **3(2):** Article 2.

Severud, F. (1961). Structures: The Feel of Things. *Journal of Architecture Education*, **16(2):** 18-22.

Schierle, G.G. (1997). The Pedagogy of Architectural Technology. *Journal of Architectural Education*, **51(2):** 82-83.

Schoenefeldt, H. (2013) A Preliminary Review of the New Studio Model Piloted in Spring. Available online at: https://www.kent.ac.uk/architecture/resources/pdf/staff/henrik.pdf [Accessed on August 24, 2013].

Silver, P. & Mclean, W. (2008). Introduction to Architectural Technology. London: Laurence King Publishing Ltd.

Singhasiri, W., Darasawang, P., & Srimavin, W. (2004). A Survey of KMUTT Architecture Students' Learning Styles : An Implication to Course Development and Classroom Teaching. Available: http://digital.lib.kmutt.ac.th/journal/kmuttv27n2_1.pdf. [Retrieved on April 16, 2012].

Shieh, S. R., Chang, W. and Liu. E.Z. (2011).Technology enabled active learning (TEAL) in Introductory physics: Impact on genders and achievement levels. *Australasian Journal of Educational Technology*, **27(7):** 1082-1099·

Shieh, S. R. (2012).The impact of Technology-Enabled Active Learning (TEAL) implementation on student learning and teachers' teaching in a high school context, Computers & Education, **59(2):** 206-214.

Shaffer, D. W. (1997). Learning mathematics through design: The anatomy of Escher's World. Journal of Mathematical Behavior, **16(2):** 95–112.

Shaffer, D. W. (2002). Design, collaboration, and computation: The design studio as a model for computer-supported collaboration in mathematics. In T. Koschmann, R. Hall, & N. Miyake (Eds.), Computer support for collaborative learning 2 (pp. 197–222). Mahwah, NJ: Erlbaum.

Shaffer, D.W. (2004). Pedagogical Praxis: The Professions as Models for Post-industrial Education. *Teachers College Record.* **106(7):**1401–1421.

Shaffer, D.W. (2005). Studio Mathematics: The Epistemology and Practice of Design Pedagogy as a Model for Mathematics Learning. WCER Working Paper No. 2005-3 Wisconsin Center for Education Research, School of Education, University of Wisconsin–Madison. Downloaded from http://www.wcer.wisc.edu/ on December 1, 2014.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher,* **15(2):** 4-14.

Smith, C. (2011) Understanding Students' Views of the Crit Assessment. *Journal for Education in The Built Environment, 6*(1), 44-67.

Smith, L. D. (1993) They will be at the mercy of engineers. *Connector: A Forum for Teachers of Technology in Schools of Architecture,* **4(2):** 3.

Steif, P. (2008). An Interactive, Cognitively Informed, Web-Based Statics Course. *International Journal of Engineering Education,* **24(6):** 1229-1241.

Syh-Jong, J. (2008). Innovations in Science Teacher Education: Effects of Integrating Technology and Team –Teaching Strategies. *Computers & Education,* **51:** 646-659.

Tashakkori, A. & Teddlie, C. (1998). *Mixed methodology: combining qualitative and quantitative approaches.* Thousand Oaks, CA: Sage.

Tonidandel, S., LeBreton, J.M., & Johnson, J.W. (2009). Determining the Statistical Significance of Relative Weights. *Psychological Methods,* **14(4):** 387–399.

Trilling, L. (1984). Technology as Part of a Liberal Education. *Technology and Science: Important Distinctions for Liberal Arts Colleges.* Davidson-Sloan New Liberal Arts Program (Davidson, North Carolina), p.70.

Tucker, R. (2006). The Impact of Teaching Models, Group Structures and Assessment Modes on Cooperative Learning in the Student Design Studio. *Journal for Education in The Built Environment,* **1(2):** 39-56.

Tucker, R. (2007). Southern Drift: The Learning Styles of First and Third-Year Students of The Built Environment. *Architecture Science Review,* **50(3):** 246-255.

Unay, A. & Ozmen, C. (2006). Building Structure Design as an Integral Part of Architecture: A Teaching Model for Students of Architecture. *International Journal of Technology and Design Education*, **16(3):** *253*–271.

University of Lagos [UNILAG]. Departmental handbook, Department of Architecture.

Uzunoglu, S.S., & Quriesh, A. (2012). A Method of Adapting Construction Education in Architectural Design Education. *Procedia – Social and Behavioural Sciences,* **51:** 546-552.

Vassigh, S. (2001). *Teaching Statics and Strength of Materials Using Digital Technology*. Paper presented at the ARCC Spring Research Conference at Virginia Tech, U.S.A. in April, 2001, pp 92-96.

Vassigh, S. (2005). A Comprehensive Approach to Teaching Structures Using Multimedia. American Institute of Architects Report on University Research 2005, Pp. 133-144.

Wang, T. (2009). Rethinking teaching with Information and Communication Technologies (ICTs) in architectural education. *Journal of Teaching and Teacher Education.* **25(8):** 1132-1140.

Webster, H. (2001). The Design Diary: Promoting Reflective Practice in the Design Studio. Architectural Education Exchange, Centre for Education in the Built Environment. Available Online at: http://www.cebe.heacademy.ac.uk/aee/pdfs/websterh.pdf [Retrieved on July 15, 2015]

Williams, S.M. (1992). Putting case-based instruction into context: Examples from legal and medical education. *The Journal of Learning Sciences*, **2(4):** 367-427.

Willis, J. (2007). The Neuroscience of Joyful Education. *Educational Leadership*. ASCD. Volume 64.

Yamane, T. (1967). *Statistics: An Introductory Analysis*, (2nd ed.). New York: Harper and Row.

Yazici, E. and Yazici, G. (2013). A "Learning By Doing" Approach in Delivery of Structural Engineering Courses of Architecture. *International Journal on New Trends in Education and Their Implications,* **4(2):** Article13.

Yazici, E. and Yazici, G. (2012). An Evaluation of the Academic Performance of Student Enrolled in the Double Major Programmes of Architecture and Civil Engineering. . *International Journal on New Trends in Education and Their Implications,* **3(4):** Article 19.

Yazici, E. and Yazici, G. (2012). The Use of Finite Analysis Applications in Architectural Education. . *International Journal on New Trends in Education and Their Implications,* **3(4):** Article14.

APPENDICES-

Appendix 1 -Student Questionnaire

THE PEDAGOGY OF ARCHITECTURAL STRUCTURES IN SELECTED SCHOOLS OF ARCHITECTURE IN NIGERIA

STUDENT SURVEY CODE......../320

Dear Respondent,

This questionnaire is designed to collect data for an on-going research on the teaching and learning of architectural structures in Nigerian Universities. Information provided will be treated confidentially, and used purely for academic purpose.

Gbenga Alalade.
Department of Architecture,
Covenant University, Ota, Ogun state.

INSTRUCTION: Please **tick (√) or fill** as appropriate

BASIC INFORMATION

1. Name of University...…………………………
2. Level of Study 100 Level…. [1], 200 Level….. [2], 300 Level…. [3], 400 Level…[4],
   MSc 1…[5, MSc 2….. [6], PGD….. [7], Ph.D….. [8],
3. Sex : Male......[1] Female.......[2]
4. Age Group (in years): 15-18____[1] 18-22____[2] 23-26____[3] Others____[4]
5. Your CGPA: (0.00-1.49)__[1], (1.50-2.49)__[2], (2.50-3.49)__[3], (3.49-4.49)__[4], (4.50-5.00)__[5]

A. PERSONAL CHARACTERISTICS: (Please indicate how the following statements apply to you):

1-Strongly Disagree [**SD**], **2**-Disagree[**D**], **3**-Undecided[**U**], **4**-Agree[**A**], **5**-Strongly Agree[**SA**]

S/N	Personal characteristics of Architecture students	SD1	D2	U3	A4	SA5
1.	I like acting first, and then **think/reflect** later					
2.	I feel deprived when cut off from **interacting** with the outside world					
3.	I am usually open to and **motivated** by the outside world, people and things					
4.	I enjoy wide **varieties** and changing **relationships** with people					
5.	I prefer outer world activities, excitements, people, & things to **1-on-1 communication**					
6.	I am mentally alive in the now &attending to **present opportunities** than **future ones**					
7.	I like using **common** sense and creating practical solutions rather than **imagining** future possibilities					
8.	My memory recall is rich in detailed facts and past events than **ordinary patterns**					
9.	I like **improvising** from past **experience** rather than **theoretical** applications					
10.	I like clear and **concrete information;** dislike **guessing** when facts are "fuzzy''					
11.	I like **categorizing, organizing, recording** and **storing** the specifics from here & now					
12.	I prefer **reality** based work, dealing with **specific** meaning of					

	things than **imaginations**					

B. LEARNING STYLES ASSESSMENT: (Please indicate how the following statements apply to you):
1-Strongly Disagree [**SD**], **2**-Disagree [**D**], **3**-Undecided [**U**], **4**-Agree [**A**], **5-**Strongly Agree [**SA**]

S/N	**Learning Styles of Architecture Students**	**SD[1]**	**D[2]**	**U[3]**	**A[4]**	**SA[5]**
1.	I feel the best way to remember things is to **picture** it in my mind					
2.	I follow **oral** direction better than **written** ones					
3.	I am constantly **fidgeting** (e.g. tapping drawing pen, playing with keys)					
4.	I prefer to **listen** to a lecture than read the materials in a textbook.					
5.	I frequently require **explanations** on sketches, diagram, graph, or maps					
6.	I work **skilfully** with my hands to make or repair things.					
7.	I often prefer to **listen** to the radio than read a newspaper.					
8.	I prefer **information** presented **visually**(-.flipcharts, electronic or chalkboard)					
9.	I usually prefer to **stand** while **working**					
11.	I am **skilful** at **designing** objects, graphs, charts and other visual displays					
12.	I talk at a fast pace and **use my hands** more to **communicate** what I want					
13.	I **frequently sing, hum or whistle** to myself					
14.	I am **excellent** at finding **my way around** even in **unfamiliar** surrounding					
15.	I am good at putting jigsaw **puzzles** together					
16.	I am always **on the move.**					
17.	I **excel** at **visual-arts**					
18.	I excel at **sports** along with **creative** works					
19.	I find it **difficult** to **sit for many hours**					
20.	I tend to **take notes** during discussions/lectures to **review** them later					

C. PERCEPTION OF TEACHING APPROACHES

I. Please indicate by ticking as appropriate the extent to which you agree with the statements in the table below:

S/N	**Structures as a Course**	**Strongly Disagree [1]**	**Disagree [2]**	**Undecided [3]**	**Agree [4]**	**Strongly Agree [5]**
1.	Places emphasis on calculations/Analyses					
2.	Is abstract/Theoretical					
3.	Is practical and easily applicable issue					
4.	Is interesting to me					
5.	Is relevant to my studies					

6.	Is necessary in my design studio work					

II. Please tick as appropriate the extent to which your personal experiences agree with the statements below:

S/N	Structures Classes/Course Content	Never [1]	Rarely [2]	Sometimes [3]	Often [4]	Always [5]
1.	I enjoy structures lectures					
2.	I participate actively in structures classes					
3.	I enjoy the theoretical aspects of structures course					
4.	I enjoy the calculations & analysis aspects of structures					
5.	I understand how to do the calculations					
6.	I undertake life project(s) for the purpose of structures					
7.	I attend field trips for the purpose of structures					
8.	I readily apply the knowledge I gain in my structures classes in my design studio projects					
9.	I like the organization of the different topics taught in structures					
10.	The times for the lecturers are very conducive to me					
11.	The format for delivery the course contents helps me to understand the course better					
12.	The organization of the lecturers helps me to develop interest and understand the course					
13	The approach(es) to teaching structures contributes to a better understanding of the course					
14	Assessment methods bring out the best in me					

D. PERCEIVED DIFFICULTIES OF STRUCTURES TOPICS

Please indicate by ticking your degree of difficulty in understanding the following areas of structures

S/N	Topics	Very Difficult [1]	Easy [2]	Not so Easy [3]	Difficult [4]	Very Easy [5]
1.	Dynamics (Forces)					
2.	Statics (Equilibrium, Support reactions)					
3.	Theory of Structures					
4.	Analysis of Statically determinate & Indeterminate structures					
5.	Design of Structural members (reinforced concrete beams/ steel beams/columns/slab)					

D. **ASSESSMENT OF TEACHING APPROACHES:** (i). Please indicate by ticking how often you use the under listed approaches for teaching structures (Leave blank if approach is not used in structures in your school)

S/N	Teaching Approaches	Never [1]	Rarely [2]	Neutral [3]	Often [4]	Always [5]
1.	Lectures					
2.	Tutorials					
3.	Liaison with fellow students-Group Based Projects					
4.	Study of structural failures					
5.	Study of historical structures					
6.	Usage of graphics					
7.	Use of models(physical,3D-Computer generated models)					
8.	Case studies from practice					
9.	Laboratory tests & investigations					
	USAGE OF ICTs FOR TEACHING STRUCTURES					
1.	Use of internet					
2.	Use of Structural Analysis & Modelling Software Applications (state……………………………………)					
3.	Use of Digital Media/Multi-media/ audio-visuals in teaching (PowerPoint, Slideshare etc)					
4.	Lecturer's website/Course website					
5.	e-learning platforms					
6.	Use of online resource materials (e-books, courseware)					
7.	Social Media- (Facebook, Tweeter, Google+, etc)					

E. **PREFERENCES FOR ARCHITECTURE COURSES** (Please indicate by ticking your level of interest)

S/N	Courses	Very Low [1]	Low [2]	Neutral [3]	High [4]	Very High [5]
1.	Structures					
2.	Building Components & Methods					
3.	Building Services					
4.	Building Climatology					
5.	History of Architecture					
6.	Design Studio					
7.	Visual Communication					

Indicate your last semester grade in structures

A….[5], B….[4], C….[3], D….[2], E….[1]

F. **PREFERENCES FOR PRE-REQUISITE 'O' LEVEL COURSES** (Please rate your level of interest)

S/N	Subjects	Very Low [1]	Low [2]	Neutral [3]	High [4]	Very High [5]
1.	Physics					
2.	Mathematics					
3.	Further Mathematics					

H. PERFORMANCE IN PRE-REQUISITE COURSES (Indicate your grade at your O'levels (WAEC/NECO/GCE)

S/N	Subjects	F[1]	E [2]	D[3]	C [4]	B [5]	A[6]
1.	Physics						
2.	Mathematics						
3.	Further Mathematics						

1. If structures is optional, would you choose it? [1] Yes [2] No

2. In your own opinion, what are the possible ways to improve students' interest, participation and understanding of structures……………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

APPENDIX 2- STAFF QUESTIONNAIRE

THE PEDAGOGY OF ARCHITECTURAL STRUCTURES IN SELECTED SCHOOLS OF ARCHITECTURE IN NIGERIA

ACADEMIC SURVEY - CODE......../20

Only for Faculty teaching Architectural Structures

Dear Respondent,

This questionnaire is designed to collect data for an on-going research on the teaching and learning of architectural structures in Nigeria universities. Information provided will be treated confidentially, and used purely for academic purpose.

Gbenga Alalade.
Department of Architecture,
Covenant University, Ota, Ogun state.

INSTRUCTION: Please **tick (√) or fill** as appropriate

A. **BASIC INFORMATION**

1. Name of University…………………………………………………………………………………………
2. Sex: Male____[1] Female___ [2]
3. Age: 21-30yrs____[1] 31-40 yrs____[2] 41-50yrs____[3] 51-60yrs_____[4] Others_____[5]
4. Highest educational attainment: HND___[1] B.Sc___[2] M.Sc___[3] PhD___[4] Others___[5]
5. Designation: Professor______ [1] Assoc. Professor______[2] Senior Lecturer_______[3] Lecturer 1_____[4] Lecturer 2______[5] Assistant Lecturer_______ [6] Others______ [7]
6. Profession: Architect_____[1] Civil/Structural Engineer_______[2] Builder_______[3]
7. Your primary area(s) of research is?
   ____
8. Have you undertaken any training course in education? No___[1], Yes___[2]
9. If your answer to Question 8 above is Yes, please identify the highest level of training?
   Certificate [ ] Diploma [ ] Degree [ ]
10. How long have you been teaching structures courses to architecture students?

Less than 1year___[1] 1-5 years___[2] 6-10 years___[3] above 10 years____[4] Others (specify)_________[5]

11. What is the level(s)/year(s) of students you teach structures this semester?
    100___[1] 200___[2] 300___[3] 400___[4] PGD___[5] Masters___[6] M.Phil/Ph.D___[7]
12. Total number of instructors teaching structures courses in your department is?
    1[ ] 2[ ] 3[ ] 4[ ] 5[ ] 6[ ]
13. The format for instruction in structure classes is primarily? (Tick as many as applicable)

Lecture___[1] Seminar____[2] Studio___[3] Tutorials____[4] Others (specify)_________[5]

14. What is the total number of hours you use in teaching structures in a week?

1[ ] 2[ ] 3[ ] 4[ ] 5[ ]

15. Do you use computer programs in teaching structures? Yes[ ] No[ ]

16. If your answer to Question 15 is Yes, specify which one you use
____

17. The standard code manual methods covered in your class for structural member evaluation is/are

BS 8110_____[1] CP 110 _____[2] CP 114______[3] BS449______[4]

BS 1881_____[5] BS 648 _____[6] BS 6399_____[7] Others (Specify) _

B. ASSESSMENT OF TEACHING APPROACHES: (i). Please indicate by ticking how often you use the under listed approaches for teaching structures (Leave blank if approach is not used in structures in your school)

S/N	Teaching Approaches	Never [1]	Rarely [2]	Neutral [3]	Often [4]	Always [5]
1.	Lectures					
2.	Tutorials					
3.	Liaison with fellow students-Group Based Projects					
4.	Study of structural failures					
5.	Study of historical structures					
6.	Usage of graphics – Sketches & pictures					
7.	Use of models(physical,3D-Computer generated models)					
8.	Case studies from practice					
9.	Laboratory tests & investigations					
	USAGE OF ICTs FOR TEACHING STRUCTURES					
1.	Use of internet					
2.	Use of Structural Analysis & Modelling Software Applications (state……………………………..………)					
3.	Use of Digital Media/Multi-media/ audio-visuals in teaching (PowerPoint, Slideshare etc)					
4.	Lecturer's website/Course website					
5.	e-learning platforms					
6.	Use of online resource materials (e-books, open courseware)					
7.	Social Media- (Facebook, Tweeter, Google^{+}, etc.)					

(ii). Please rate the extent to which you agree with the use of Software applications in teaching structures?

S/N	USE OF SOFTWARE APPLICATIONS	Strongly Disagree [1]	Disagree [2]	Undecided [3]	Agree [4]	Strongly Agree [5]
1.	Software applications should be used to simulate the behaviour of structural systems and build intuitive speculation					
2.	Software applications should be used to complement manual / computational method					
3.	Software applications should be used only for verification of manual computation					

4.	Software applications should be used to make computations more efficient and understandable					
5.	Software applications should be used primarily in conjunction with studio design projects					

C. EMPHASIS OF COURSE CONTENT

Please indicate by ticking the extent of emphasis of the following in your approach to teaching structures

S/N	EMPHASIS	Very Low [1]	Low[2]	Neutral [3]	High [4]	Very High [5]
1.	Quantitative / mathematical based evaluation and analysis of structural members of frames.					
2.	Qualitative and intuitive understanding of the behaviour of structural systems and materials					
3.	Developing student's ability to select and propose structural system for buildings					
4.	The utilization of computer simulations in the understanding of structural behaviours					
5.	Providing overview of historical development of structural systems and materials					
6.	Understand the implications of structural systems/forms in the design of buildings					

D. ASSESSMENT OF THE REQUISITE STRUCTURAL SKILLS FOR GRADUATE ARCHITECTS

(Please indicate by ticking (√) the likely importance of the following skills for architectural practice)

S/N	Structural Skills/Competencies	Completely Unimportant [1]	Not Important [2]	Somehow Important [3]	Important [4]	Extremely important [5]
1	Layout of Structural members					
2	Roof Design					
3	Impact of Structural systems on Architectural Form					
4	Behaviour of Structural Materials					

5	Principles of Structural Stability/Integrity					
6	Economy in the use of Structural Materials					
7	Aesthetics of Structural Materials					
8	Design of reinforced concrete members					
9	Design of structural steel members					
10	Design of structural timber members					
11	Design of Composite structural members					
12	Design of Structural glass members					

E. ASSESSMENT OF GRADUATING STUDENTS (B.Sc/M.Sc) STRUCTURAL COMPETENCE

Please indicate by ticking (√) the extent of the structural competence of your graduating students.

S/N	Structural Skills/Competencies	Assessment of Graduate Architect's Competence				
		Very Low [1]	**Low [2]**	**Neutral [3]**	**High [4]**	**Very High [5]**
1	Layout of Structural members					
2	Roof Design					
3	Impact of Structural systems on Architectural Form					
4	Behaviour of Structural Materials					
5	Principles of Structural Stability/Integrity					
6	Economy in the use of Structural Materials					
7	Aesthetics of Structural Materials					
8	Design of reinforced concrete members					
9	Design of structural steel members					
10	Design of structural timber members					
11	Design of Composite structural members					
12	Design of Structural glass members					

F. INTEGRATION OF TECHNICAL COURSES

(Please indicate by ticking the extent to which you agree with following statements)

S/N		Strongly disagree [1]	Disagree [2]	Undecided [3]	Agree [4]	Strongly agree [5]
1.	Technical courses have been well integrated into the design studio course					
2.	Closer integration is needed in the design process and studio instruction					
3.	Students need to be conceptual designer, technical issues can be learned in practice					

G. PERSONAL OPINIONS ON TEACHING OF STRUCTURES

Based on your experience in the teaching of structures, what are the possible ways to improve students' interest, participation and understanding of structures?

1. ____
2. ____
3. ____

Appendix 3- Industry Survey/Expert Opinion

THE PEDAGOGY OF ARCHITECTURAL STRUCTURES IN SELECTED SCHOOLS OF ARCHITECTURE IN NIGERIA

INDUSTRY SURVEY CODE......../20

Dear Respondent,

This questionnaire is designed to collect data on issues relating to the teaching and learning of architectural structures. Information provided will be treated confidentially, and used purely for academic purpose.

Gbenga Alalade. Department of Architecture, Covenant University, Ota, Ogun state.

ASSESSMENT OF THE REQUISITE STRUCTURAL SKILLS FOR GRADUATE ARCHITECTS

1. Please tick (√) the likely importance of the following skills for architectural practice.

S/N	Structural Skills/Competencies	Assessment of likely importance for practice				
		Completely Unimportant [1]	**Not Important [2]**	**Somehow Important [3]**	**Important [4]**	**Extremely Important [5]**
1	Layout of Structural members					
2	Roof Design					
3	Impact of Structural systems on Architectural Form					
4	Behaviour of Structural Materials					
5	Principles of Structural Stability/Integrity					
6	Economy in the use of Structural Materials					
7	Aesthetics of Structural Materials					
8	Design of reinforced concrete members					
9	Design of structural steel members					
10	Design of structural timber members					
11	Design of Composite structural members					
12	Design of Structural glass members					

2. Please tick (√) the extent of competence of the graduate architects working for/with you in the following skills.

S/N	Structural Skills/Competencies	Assessment of Graduate Architect's Competence				
		Very Low [1]	**Low [2]**	**Neutral [3]**	**High [4]**	**Very High [5]**
1	Layout of Structural members					
2	Roof Design					
3	Impact of Structural systems on Architectural Form					
4	Behaviour of Structural Materials					
5	Principles of Structural Stability/Integrity					
6	Economy in the use of Structural Materials					
7	Aesthetics of Structural Materials					
8	Design of reinforced concrete members					
9	Design of structural steel members					
10	Design of structural timber members					
11	Design of Composite structural members					
12	Design of Structural glass members					

Appendix 4 : NUC Architectural Structures Course Description

B.Sc.		
S/N	**COURSE**	**CONTENT**
1.	NA	***BUILDING STRUCTURES I/II*** Fundamentals of strength of materials with emphasis on their applications to architectural structures. Intuitive, qualitative and quantitative approaches to structural mechanics, force flow and structural configurations.
2.	NA	***BUILDING STRUCTURES III/IV*** A lecture/laboratory course to develop understanding of the behavior of timber, steel and reinforced concrete in structures, to design simple structural elements of these materials and to develop graphic skills in the presentation of design results.
3.	NA	***BUILDING STRUCTURES V/VI*** Approximate analysis for the various structural systems (form-active, vector-active, bulk-active, surface-active and vertical structure) to illustrate design criteria needed for architectural decisions. The relationship between structural behavior and structural form. The morphology of forms will be discussed using both natural and man-made forms as examples. Economics and aesthetic suitability as applied to architectural problems.

Source: **Benchmark Minimum Academic Standards for Architecture in Nigerian Universities *for* Environmental Sciences - National Universities Commission, April, 2007**

Appendix 5: CU Structures Course Description

Graduation Requirement for Architecture Program, Covenant University

B.Sc.		
S/N	**COURSE**	**CONTENT**
1.	ARC 215 (*2 Units*)	***BUILDING STRUCTURES I*** MODULE 1: **Review of Forces, Moments and Couples as applied to Building structures** - The concept of Force, Moments, Couples, Statics and Static Equilibrium and their applications to Building Structures. MODULE 2: **Building as a key Component of The Built Environment**-Components of Building, Theory of Structures, Structural Modeling and its Application; Forces as loads on Structures. MODULE 3: **Basic Structural Elements**- Beams, Columns, Arches, Trusses, Shells, Plates and Slabs their Properties and Applications. MODULE 4: **Structural Systems in Buildings** – Historical Evolution and Applications of Structural systems, Contributions of Ancient Egyptians, Greeks, Romans, Industrial Revolution and others to the Evolution of structural Systems. MODULE 5: **Simple Support Systems**- Characteristics and Applications of Roller, Pinned and Fixed supports; Classification of Beams base support systems (Statically Determinate and Indeterminate Beams). MODULE 6: **Types of Simple Structures**- Characteristics and Applications of Solid, Skeletal, Cables, Arches, Shells, Pneumatic structures.
	ARC 225 (*2 Units*)	***BUILDING STRUCTURES II*** MODULE 1: **Load on Structures**-Stress, Strain and Shear as applied to Structures. Hooke"s Law; Young Modulus; Stress-Strain Curve and its applications. Mechanical Properties of Materials (Elasticity, Plasticity, Ductility; Brittleness, Resilience, Hardness, Toughness). MODULE 2: **Properties of Cross-Sections of Structural Elements-**Centre of Gravity, Centriod and Moment of Areas. MODULE 3: **Beam as a simple Structural Element**-Statically determinant and Indeterminate Beams; Stress in Beams, The Concept and importance of Critical Sections of

		Beams, Shear and Bending Stresses in Critical Sections of beams. Determination of Shear and Bending Moments in Beams using Bending Moment and Shear force Diagrams.
2.	ARC 315 (*2 Units*)	***BUILDING STRUCTURES III*** A continuation of ARC 225, but with emphasis on determination of loads on building structures using different analytical methods. MODULE 1: **Statically Determinate and Indeterminate Structures**-Determination of loads on structures. MODULE 2: **Introduction to Frame Structures and their Applications**-Pin Jointed Frame Structures. Analysis of Trusses. MODULE 3: **Introduction to slope and Deflection of Prismatic Beams**-Analysis of determinate beams using formula method and Method of Superposition. MODULE 4: **Statically Determinate Beams**: Analysis of Statically indeterminate Beams using methods of Superposition, Three Moment Theorem and Moment Distribution.
	ARC 325 (*2 Units*)	***BUILDING STRUCTURES IV*** MODULE 1: **Introduction to Reinforced Concrete Design**- Reinforced Concrete design methods. MODULE 2: **Properties and Structural Behaviour of Concrete and Steel**- Tensile, Comprehensive, Shear, Fire Resistant Properties etc. MODULE 3: **Limit State Design According to BS8110**- Concepts and Terminologies used in Reinforced Concrete Design according to BS8110. MODULE 4: **Design of Reinforced Concrete Beams**- Singly and Doubly Reinforced Beams, Design of Bending and Shear reinforcements; Design of Continuous Beams
3.	ARC 415 (*3 Units*)	***BUILDING STRUCTURES V*** MODULE 1: **Reinforced Concrete Slabs**- Design of reinforced concrete

		slabs. MODULE 2: **Foundations**- Design of reinforced Concrete Pad Foundation. MODULE 3: Design of Reinforced Concrete Columns. MODULE 4: **Introduction to principle of design of Retaining Walls**. Design of Structural drawings of simple Buildings
	ARC 425 (3 *Units*)	***BUILDING STRUCTURES VI*** The design of structural Steel and Timber Elements are taught in this course. MODULE 1: **Design of Structural Steel Elements**- Design of Steel Beams and Joists. MODULE 2: **Design of Structural Timber Elements**- Design of Timber Columns, Beams and Studs
MS.c		
4.	ARC 813 (3 *Units*)	***BUILDING STRUCTURES VII*** Introduction to the principles of structural aesthetics, relationship between structure and form. The concept of structural form as dictated by material, technology and behaviour of structure and form in architecture are studied. Innovative structural systems as applied in buildings are studied e.g Wind-Force Resisting System, Lateral –force Resisting systems and Seismic-force Resisting systems . Students are introduced to the basic principles and applications of 2-Dimensions and 3-Dimension structures; and integration of building structure and envelope. Case studies from life projects are examined.

Source: Department of Architecture, Covenant University, Student Handbook. (2015)

Appendix 6: FUTA Structures Course Description

Graduation Requirement for Architecture Program, Federal University of Technology Akure

B.Sc.		
S/N	**COURSE**	**CONTENT**
1.	***ARC 211*** ***(2 Units)***	***THEORY OF STRUCTURES I*** The course is an empirical introduction to the understanding of structural action and potential of materials, with an emphasis on structure as an integral part of architectural design, it deals with basic definition of structural elements and systems, resisting deformation, stability, historical development of structure and interdisciplinary design process. Properties of materials- tensile, compressive, shear stresses and strain in simple structures. Stresses and deflations in beams restrained and continuous beam.
	ARC 212 ***(2 Units)***	***THEORY OF STRUCTURES II*** An introduction to design of structures, definition, conventions, the rational analysis of structural members of system, a common language for discussion. Calculation is kept to a necessary minimum, instead concentrating on imbuing understanding that will allow rational decision making in the architectural design process. And overlap with a studio work project illustrates the process of basic statics and the application of statics to the determination of reactions, shears and moments. Stresses in trussed structures. Introduction to the analysis of statically indeterminate structures the moment area theorems, conjugate beam and moment distribution.
2.	***ARC 304*** ***(3 Units)***	***BUILDING STRUCTURES: REINFORCED CONCRETE DESIGN*** Introduction to the theory and design of simple reinforced concrete structures: Development of elastic theory of R.C beams, slabs and columns. Understanding the behavior of R.C structures and development of graphic skills in the presentation of design results. Load path,

		functions of various types of members, reasons behind shapes of members, why they become unserviceable and fall, theory and demonstration, how members fall-loss of equilibrium.
3.	***ARC 411*** ***(3 Units)***	***BUILDING STRUCTURES: STEEL AND TIMBER DESIGN*** Application of principles of structural design and analysis of members used in contemporary timber and steel-frame buildings. Design of beam girders and trusses. Welded and riveted connections, columns, bearing plates, etc. theories of wind braces and effect on building design. Topics also include design for stability in structure; trusses and lattice girders, space frame and rigid frames; plates and shells; cables, tent and arch structures; foundations and retaining walls; design dependence on method of construction.

Source: Department of Architecture, FUTA, Student Handbook.

Appendix 7: OAU Structures Course Description

Graduation Requirement for Architecture Program, Obefemi Awolowo University

B.Sc.		
S/N	**COURSE**	**CONTENT**
1.	ARC 211 (*3 Units*)	***ARCHITECTURAL STRUCTURES I*** Introduction to the mechanics and design of building structures. The object of structural design. Statics of particles-Forces in a plane and Forces in space. Static of Rigid bodies in two dimensions. Statics of Rigid bodies in three dimensions. Properties of structural section, of Area, Moments of Inertia, sections-centroid. First Moment of Area, Moments of Inertia, Compound Sections, Radius of Gyration, Polar Moment of Inertia, Section Modulus, Principal Axes and principal Moments of Inertia. Mohr's Circle for Moment and Products of Inertia.
	ARC 212 (*3 Units*)	***ARCHITECTURAL STRUCTURES II***

		Shearing stresses. Analysis of stress and strain (2/3 dimensional). Longitudinal stresses in beams. Shearing Stresses in Beams. Beams of Two Materials. Combined Bending, Direct Stresses. Torsion. The Principle of Virtual Work and its Application, Strain Energy/Complementary Energy. Deflection of Statically Determinate Beams. Elastic Buckling of Columns and Beams. Vibration in Beams.
2.	ARC 311 (*3 Units*)	***ARCHITECTURAL STRUCTURES III*** This course introduces the student to the various types of structural forms to enable him/her make a systematic classification of approaches to structural decisions, in relation to architectural design. Survey of various structural systems used in building of various types. Basic principles of each system are in building of various including its relationship to spatial quality and the historical development of the system. Topics covered among others will include the following: Structural forms – solid structures, skeletal structures, surface structures. Innovative structural system – Arches, Domes, Cables, Shells Pneumatic structures, etc.
	ARC 312 (*3 Units*)	***ARCHITECTURAL STRUCTURES 1V*** The objective of this course is to acquaint students with structural analysis which will allow them to take effective design decisions. It is an in-depth study of the behavior of structures under different types of loading. Topics covered are: Shear and Moment Diagrams. Relationships and Load, Shear and Bending moments. Analysis of Indeterminate Structures. Using slope – deflection and moment – distribution methods.
4.	ARC 409 (*3 Units*)	***ARCHITECTURAL STRUCTURES V*** Introduction to structural Timber, Analysis of stresses on wood. Properties of Timber and Wood – 'based materials structural forms and

		design of Timber. Solid structures, skeletal structures, Trusses and Girders'. Portal frames and arches. Spatial structures, surface structures. Design of joints in structural Timber. Criteria for selection of structural systems, Design and behavior of steel structural members, Design for Flexure. Design of compression members.
	ARC 410 (*3 Units*)	***ARCHITECTURAL STRUCTURES VI*** Review of the properties and behavior of concrete and steel – Strength, durability, effect of temperature. Examination of reinforced concrete design philosophies – working stress. Limit state ultimate strength etc. Design of one way and two way slabs, Design of beams, for tension and compression columns and foundations.

Source: Department of Architecture Student, OAU, Handbook,

Appendix 8: UNILAG Structures Course Description

Graduation Requirement for Architecture Program, University of Lagos

B.Sc.		
S/N	**COURSE**	**CONTENT**
1.	ARC 231 (*2 Units*)	**STRUCTURES I** An introductory course to the relationship between architectural forms and structures. A thorough application of the various geometrical elements to develop structural forms. Contemporary trends in structural forms as basis for architectural forms and space.
	ARC 232 (*2 Units*)	**STRUCTURES II** A study of the internal effects produced based on the strength of each materials, such as the deformations of bodies caused by externally applied forces. Stresses and Strains, Geometric properties of sections, centroids and moments of inertia, shearing forces, torsion and bending moments generated in a beam. Analysis of determinate and indeterminate structures.
2.	ARC 331 (*2 Units*)	**STRUCTURES III** Understanding the structural properties of timber and steel. Application of the principle of structural analysis and design using the established codes of design in timber and steel. Connectors used in timber and steel.
3.	ARC 431 (*2 Units*)	**STRUCTURES 1V** Introduction to the theory of simple reinforced concrete structures. The general types of loading (dead loads, live loads and wind load). The criteria used in the various analysis and calculation of loads. Design of slab, beam, column, and foundation in accordance with the philosophy of reinforced concrete design in the code of practice. Pre-stressed concrete, pile foundation, effects of acid rain and hollow pot slab.
M.Sc.		
4.	ARC 831 (*2 Units*)	**ADVANCED STRUCTURES** In-depth study of structural elements, the behavior of various structural

		systems and materials. Construction methods of contemporary structures in timber, steel, reinforced concrete and precast concrete.

Source: Department of Architecture, UNILAG, Student Handbook,

Appendix 9: Alternative 1- Regression Coefficients of Predictors of Structural Literacy: Learning Outcome (measured by Test Score)

Model Summary

Multiple R	R Square	Adjusted R Square	Apparent Prediction Error
.496	.247	.165	.753

Dependent Variable: Last Semester Grade

Independent variables	**Standardized Coefficients**		**df**	**F**	**Sig.**
	Beta	**Std. Error**			
Lecture Based Instruction	.101	.140	1	.522	.471
Project Based Instruction	.052	.213	2	.059	.943
Case Based Instruction	.305	.214	5	2.027	.075
Visual Based Instruction	-.274	.220	3	1.557	.200
Curriculum- Relative weight of Structures credit units to graduation benchmark	.075	.119	1	.395	.530
Use of ICT	-.192	.203	2	.895	.410
Level of Study	-.176	.127	1	1.932	.166
Gender	.008	.042	1	.033	.855
Age grouping	.067	.133	1	.255	.614
Students Overall Academic Performance (CGPA)	.339	.070	2	23.112	.000
Personal Profile (Extrovert-Introvert)	-.074	.143	1	.268	.605
Personal Profile (Sensing- Intuition	-.061	.148	2	.170	.844
Learning Style (Diverger- Converger)	.106	.143	4	.546	.702
Learning Style (Accommodator-Assimilator)	.144	.163	4	.778	.540

Dependent Variable: Last Semester Grade

Appendix 10:

Alternative 1- Regression Coefficients of Predictors of Structural Competency: Learning Outcome (measured by Application of Structures Knowledge to Design Studio)

4. Model Summary

Multiple R	R Square	Adjusted R Square	Apparent Prediction Error
.500	.250	.163	.750

Dependent Variable: I readily apply the knowledge i gain in my structures classes in my design studio projects

Independent Variables	**Standardized Coefficients**		**df**	**F**	**Sig.**
	Beta	**Std. Error**			
Lecture Based Instruction	.203	.076	4	7.058	.000
Project Based Instruction	-.341	.157	3	4.711	.003
Case Based Instruction	.142	.151	4	.884	.474
Visual Based Instruction	.066	.200	3	.108	.956
Curriculum-Relative weight of Structures credit units to graduation benchmark	-.044	.095	1	.216	.643
Use of ICT	.316	.184	3	2.948	.033
Level of Study	-.114	.114	2	1.017	.363
Gender	.058	.056	1	1.086	.298
Age grouping	.128	.143	1	.795	.373
Your CGPA	-.085	.105	2	.659	.518
Personal Profile (Extrovert-Introvert)	-.105	.115	3	.840	.473
Personal Profile (Sensing- Intuition	.175	.107	3	2.701	.046
Learning Style (Diverger- Converger)	.124	.196	1	.399	.528
Learning Style (Accommodator-Assimilator)	-.132	.186	1	.503	.479

Dependent Variable: I readily apply the knowledge i gain in my structures classes in my design studio projects

Appendix 11:

Alternative 2- Regression Coefficients of Predictors of Structural Literacy: Learning Outcome (measured by Test Score)

5.Model Summary

Multiple R	R Square	Adjusted R Square	Apparent Prediction Error
.669	.448	.279	.552

Dependent Variable: Last Semester Grade

Independent Variables	**Standardized Coefficients**		**df**	**F**	**Sig.**
	Beta	**Std. Error**			
Lecture based instruction	-.085	.141	2	.359	.699
Project based instruction	.184	.207	3	.790	.500
Case based instruction	.139	.282	5	.243	.943
Visual based instruction	-.136	.226	3	.365	.778
Relative weight of Structures credit units to graduation benchmark	.103	.102	1	1.023	.313
Use of ICTs	-.122	.191	1	.408	.524
Level of Study	-.101	.165	1	.374	.541
Gender	.021	.049	1	.182	.670
Age grouping	.127	.165	1	.597	.441
Your CGPA	.240	.080	2	8.974	.000
Personal Profile (Extrovert-Introvert)	.088	.140	3	.394	.758
Personal Profile (Sensing- Intuition	-.061	.142	2	.186	.830
Learning Style (Diverger- Converger)	.081	.142	3	.327	.806
Learning Style (Accommodator-Assimilator)	.072	.157	2	.212	.809
Places emphasis on calculations/Analyses	-.110	.119	2	.850	.429
Is Abstract/theoretical	-.091	.117	3	.605	.612
Is practical and easily applicable issue	-.127	.163	3	.613	.607
Is interesting to me	.338	.121	3	7.801	.000
Is relevant to my studies	.151	.164	2	.843	.432
Is necessary to my design studio work	-.111	.155	2	.511	.600
I enjoy structures lectures	-.168	.179	2	.880	.416
I participate actively in structures classes	.186	.097	3	3.683	.013

I enjoy the theoretical aspects of structures course	.030	.164	3	.034	.992
I understand how to do calculations	.157	.174	2	.813	.445
I understand how to do the calculations	.058	.164	1	.127	.722
I undertake life project(s) for the purpose of structures	.099	.150	1	.431	.512
I attend field trips for the purpose of structures	-.151	.126	1	1.430	.233
I readily apply the knowledge i gain in my structures classes in my design studio projects	.053	.128	1	.173	.678
I like the organization of different topics taught in structures	-.107	.150	2	.507	.603
The time for the lecturers are very conducive to me	-.165	.143	3	1.326	.267
The format for delivery the course contents helps me to develop interest and understand the course	.172	.141	3	1.497	.216
The organization of the lecturers helps me to develop interest and understand course	-.057	.161	1	.125	.724
The approach(es) to teaching structures contributes to a better understanding of the course	-.070	.145	2	.234	.791
Assessment methods bring out the best in me	.061	.125	2	.236	.790

Dependent Variable: Last Semester Grade

Appendix 12:

Alternative 2- Regression Coefficients of Predictors of Structural Competency: Learning Outcome (measured by Application of Structures Knowledge to Design Studio)

Independent Variables	Standardized Coefficients		df	F	Sig.
	Beta	Std. Error			
Lecture Based Instruction	.127	.121	3	1.101	.350
Project Based Instruction	-.308	.192	5	2.554	.028
Case Based Instruction	.020	.223	1	.008	.928
Visual Based Instruction	.085	.141	3	.363	.780
Curriculum-Relative weight of Structures credit units to graduation benchmark	.026	.101	1	.067	.796
Use of ICT	.239	.214	1	1.243	.266
Level of Study	.021	.110	2	.037	.963
Gender	.000	.051	1	.000	.997
Age grouping	.077	.116	1	.436	.510
Your CGPA	-.109	.068	3	2.554	.056
Personal Profile (Extrovert-Introvert)	-.090	.126	4	.511	.728
Personal Profile (Sensing- Intuition	.148	.067	3	4.829	.003
Learning Style (Diverger-Converger)	.091	.147	2	.383	.682
Learning Style (Accommodator-Assimilator)	-.068	.140	3	.234	.873
Places emphasis on calculations/Analyses	-.093	.120	3	.600	.615
Is Abstract/theoretical	-.139	.084	3	2.763	.043
Is practical and easily applicable issue	-.073	.130	3	.313	.816
Is interesting to me	.213	.129	3	2.734	.044
Is relevant to my studies	.052	.136	1	.146	.703
Is necessary to my design studio work	.242	.110	3	4.826	.003
I enjoy structures lectures	.116	.162	3	.517	.671
I participate actively in structures classes	-.066	.138	1	.231	.631
I enjoy the theoretical aspects of structures course	.027	.129	2	.043	.958
I understand how to do calculations	-.109	.158	3	.474	.700
I understand how to do the calculations	.049	.121	2	.167	.847
I undertake life project(s) for the purpose of structures	.058	.128	1	.202	.654
I attend field trips for the purpose of structures	.170	.093	2	3.333	.037

I like the organization of different topics taught in structures	.126	.115	2	1.198	.304
The time for the lecturers are very conducive to me	.033	.121	2	.072	.930
The format for delivery the course contents helps me to develop interest and understand the course	.005	.159	1	.001	.973
The organization of the lecturers helps me to develop interest and understand course	-.092	.144	4	.412	.800
The approach (es) to teaching structures contributes to a better understanding of the course	.007	.145	2	.002	.998
Assessment methods bring out the best in me	.090	.098	3	.847	.470

Dependent Variable: I readily apply the knowledge i gain in my structures classes in my design studio projects

Appendix 13:

Regression Coefficients of Predictors of Structural Proficiency: Learning Outcome (measured by a combination of Application of Structures Knowledge to Design Studio and Test Score)

Model Summary

Multiple R	R Square	Adjusted R Square	Apparent Prediction Error
.669	.447	.352	.553

Dependent Variable: Overall Learning Outcome

Independent Variable	**Standardized Coefficients**		**dF**	**F**	**Sig.**
	Beta	Std. Error			
Lecture Based Instruction	.075	.071	2	1.099	.335
Project Based Instruction	-.132	.085	2	2.424	.091
Case Based Instruction	-.067	.133	2	.253	.777
Visual Based Instruction	.164	.081	4	4.063	.003*
Student Perception of Teaching Approaches	.023	.193	2	.014	.986
Student Perception of Content	.307	.077	3	15.891	.000*
Use of ICT	.064	.105	1	.369	.544

Personal Profile (extrovert-introvert)	-.136	.066	4	4.251	.002*
Personal Profile (Sensing-Intuition)	.100	.107	2	.877	.417
Learning Style (Diverger - Converger)	-.048	.117	2	.168	.846
Learning Style (Accommodator-Assimilator)	.155	.067	3	5.369	.001*
Curriculum- Relative weight of Structures credit units to graduation benchmark	.045	.073	2	.378	.686
Level of Study	.113	.086	2	1.730	.179
Gender	-.066	.058	2	1.301	.274
Age Grouping	-.012	.111	1	.012	.912
Students Overall Academic Performance (CGPA)	.090	.056	2	2.551	.080
Level of Interest	.271	.126	3	4.641	.004*
Relevance of Structures to Design Studio	.156	.090	3	2.964	.033*
Area of emphasis in teaching	-.088	.101	3	.757	.519

Dependent Variable: Structural Proficiency: Overall Learning Outcome (measured by a combination of Application of Structures Knowledge to Design Studio and Test Score)
*Significant $P<0.005$