Curricular Anatomy of the CAD Proficient Architecture Graduate in Nigeria

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Abstract

The production of CAD proficient graduates by Nigerian Schools of Architecture will require a thorough review of the current curriculum to make CAD an integral part of the training programme. Global trends, improvement in computer technology and lower cost of entry have made the production of CAD proficient graduates possible within our current resources. This paper describes the computer courses required for CAD proficiency and compares these with the computer courses offered in Nigerian schools of architecture. An analysis of the computer curriculum of some schools of architecture in foreign countries was carried out. A computer curriculum is proposed with a clear distinction between regular courses and components integrated into studio and practical courses. The paper also deliberates on implementation strategies including the facilities required, maintenance, funding and the role of the professional bodies. In conclusion, the production of CAD proficient architecture graduates is seen as feasible, even imminent.

Keywords: architectural education, CAD, curriculum, Nigeria, software.

1. Introduction

The need to improve the curriculum of Architecture courses has been the subject of heated discourse and strategic positioning over the last decade (Chukwuali, 2001; Mbina, 1997; Nkwogu, 2003; Ogunsote and Prucnal-Ogunsote, 1987; Okedele and Adejimi, 2002; Olusanya, 1999; Otitoola, 2000; Sa'ad, 2001; Solanke, 2001 and Uji, 2001). Many of the champions of change are in a position to implement their visions, and so there has been a gradual realignment of the curriculum to 21st century realities. There is general agreement on the need to introduce CAD proficiency into the curriculum, but the extent and rate are still the subject of debate (Ogunsote, 2001b). The issue of lack of a standard curriculum for CAD raised by Ogunsote and Prucnal-Ogunsote (2004) should however be urgently addressed.

A very problematic area is whether or not students should be allowed to produce only CAD versions of their final year projects, given the ease with which projects can be copied from the Internet. This paper proposes that graduates of architecture should acquire CAD proficiency as part of their regular training. This will involve integration of CAD related courses into every year of the training programme. It is assumed that all projects may be presented in CAD format as the preferred option.

2. Computer Aided Architectural Presentation (CAAP) Software

Ogunsote and Prucnal-Ogunsote (2002) identified the categories of Computer Aided Architectural Presentation (CAAP) software. These categories can be grouped into two classes: CAD software and graphics software (Table 1).

Table 1: Computer Aided Architectural Presentation software categories.

Category	Software
CAD Software	2D and 3D modelling software, Rendering software, Animation software
Graphics Software	Bitmap (photo) editing software, vector graphics software, presentation software, desktop publishing software, device drivers, software tools

Source: Field studies.

2.1 CAD Software

Examples of CAD software are shown in Table 2. Proficiency in this software should be acquired directly in departments.

Table 2: Examples of CAD software.

Category	Examples of Software
2D and 3D architectural modelling software	3D Home Architect, *AutoCAD, Autodesk Architectural Desktop, Autodesk Revit Building, *ArchiCAD, Form-Z, TurboCAD.
Rendering software	3D Studio Viz, *AutoDesk 3D Studio Max, Accurender, AutoDesk Architectural Desktop, ArchiCAD, AutoCAD, Form-Z, TurboCAD.
Animation software	Amorphiurn , *AutoDesk 3D Studio Max, Autodesk Architectural Desktop, Blender, Bryce, Corel Photo Paint, Flash, Poser, Ray Dream Studio, SoftImage XS1,True Space.

Source: Field studies. The * represents most popular software. Most animation software can model and render.

2.2 Graphics Software

It is possible to offer courses in graphics to several departments at once. Examples of graphics software are shown in Table 3.

Table 3: Examples of graphics software

Category	Examples of Software
Bitmap (photo) editing software	Adobe PhotoShop, Microsoft Paint, Corel Photo Paint, MicroGrafx Picture Publisher.
Vector graphics software	Corel Draw!, Micrografx Designer.
Presentation software	Microsoft Power Point, Harvard Graphics.
Desktop publishing software	Adobe PageMaker, Microsoft Publisher.
Device drivers	HP PhotoReal, Adobe Postscript, Scanner drivers, Digital camera drivers.
Software tools	Acrobat distiller, Acrobat Reader, Imaging for Windows.

Source: Field studies.

3. Courses Required for CAD Proficiency

CAD proficiency requires expertise in the following areas:

- Basic computer literacy
- CAD concepts and theory
- Graphics software
- 2D CAD
- 3D CAD and visualization

There are some basic skills that should be acquired by all students of architecture, planning and engineering. These skills can be acquired through common courses. The more advanced skills should however be taught within the departmental. CAD is best taught directly by each department, but there are circumstances where it is more efficient to offer some courses as service courses to several departments.

3.1 Basic Computer Literacy

Every graduate should have a certain minimum level of computer literacy which must be part of the training provided by the institution. While mathematics and some form of computing and programming is now part of most curricula, the focus and content are outdated. It is recommended that the following courses should be taught to all 100 and 200 Level students in tertiary institutions:

- **Computer Appreciation**. This course should teach the basics and history of computing, including familiarisation with the hardware and software. At the end, students should be able to work independently on a computer performing simple tasks.
- **Operating Systems**. This should cover the latest or recent version of *Microsoft Windows* and other operating systems as applicable. At the end students should be able to work freely in a *Windows* environment, even without a pointing device.
- **Internet Appreciation**. Each student should be able to work freely on the World Wide Web using email, chat rooms, search engines and directories after the course.
- **Application Packages**. Every student should learn how to use the most popular word-processing, spreadsheet, database and presentation software. This may include *Microsoft Word, Microsoft Excel, Microsoft Access* and *Microsoft PowerPoint*. At the end students should be able to independently produce professional documents using the application packages.

These courses can be packaged into full-semester courses, but the tendency in developed countries is to provide short courses for which students receive low credits. Each student would therefore have to attend several of such short courses to make up the minimum number of credits required.

3.2 CAD concepts and theory

There are several concepts and theoretical constructs that form the basis of CAD software. While these concepts are best understood when demonstrated on a computer,

it is important to teach these concepts in a classroom environment. Good understanding of these concepts is essential in understanding and using CAD software. A workshop environment where theory can be discussed and concepts demonstrated is best. However, these concepts can still be taught successfully where there are very few computers.

Courses covering these concepts can be offered centrally to several departments with mainly lectures, practicals, assignments and written examination as components. The courses may for example be named Introduction to Computer Aided Draughting, CAD Concepts and Methods, Advanced CAD Concepts and Methods, et cetera. While examples should be given using a popular package like *AutoCAD*, the course content should be generally applicable to most CAD software.

3.3 Graphics Software

Even the best CAD design will lose its impact if poorly presented. Many aspects of students' training also require advanced skills in report writing, sketching, formatting and presentation. A good knowledge of graphics software such as *Adobe PageMaker, Adobe PhotoShop, Corel Draw!, Corel Photo Paint, Harvard Graphics, Micrografx Designer, MicroGrafx Picture Publisher, Microsoft Paint, Microsoft Power Point* and *Microsoft Publisher* is essential. These courses are best offered as common courses.

3.4 2D CAD

Proficiency in two-dimensional (2D) Computer Aided Draughting includes the ability to independently produce basic drawings such as plans, elevations, sections, details and schedules at a professional level. Mastering CAD software such as AutoCAD is essential. This course can be offered at departmental level or as a common course depending on student population and facilities available.

3.5 3D CAD and visualization

This covers the ability to produce life-size and detailed models of buildings and complexes using advanced techniques including daylighting, artificial lighting, materials and landscape elements such as plants, people, animals and vehicles (Wikipedia, 2006). Students should be able to produce photo-realistic renderings and animations at a professional level. Mastering CAD software such as AutoCAD, ArchiCAD, 3D Studio Max and Autodesk Architectural Desktop is essential. This course can be offered at departmental level or as a common course depending on student population and facilities available.

4. Current Computer Curriculum in Nigerian Schools of Architecture

Many Nigerian schools of architecture have computer courses in their curricula. However, many of these courses are taught outside the department. The course content is often suitable for science and engineering students, but not for architecture students. The computer courses being taught by other departments are gradually being transferred to the department to be taught by architects. Computer Courses in the architecture curriculum of selected universities are shown in table 4.

Table 4: Computer Courses in the Architecture Curriculum of Selected Universities

University	Computer Courses offered
Abubakar Tafawa Balewa University, Bauchi	CS 142: Introduction to Computer Science ARC 512: AutoCAD I
Ahmadu Bello University, Zaria	ARCH 121: Introduction to Basic Computer ARCH 122: Introduction to Basic Computing ARCH 327: Introduction to CAD ARCH 328: Introduction to CAD ARCH 453: Computer Aided Design
Ambrose Alli University, Ekpoma	MTH 103: Introduction to Computer ARC 755: AutoCAD (MSc II)
Federal University of Technology, Akure	IMC 142: Introductory Computer Science IMC 241: Computer Programming I
Federal University of Technology, Minna	CPT 121: Introduction to Computer Science I CPT 213: Introduction to Computer Science II ARC 614: Advanced Computer Aided Design I ARC 624: Advanced Computer Aided Design II
Federal University of Technology, Yola	CS101: Introduction to Computer Science I CS102: Introduction to Computer Science II CS201: Computer Programming I CS202: Computer Programming II AR513: Computer in Architecture I AR508: Computer in Architecture II
Obafemi Awolowo University, Ile Ife	ARC 668: Computers in Architecture
Olabisi Onabanjo University, Ibogun Campus	CSC 201: Computer Programming I CSC 202: Computer Programming II GNS 203: Introduction to Computer I GNS 204: Introduction to Computer Application ARC 307: Introduction to AutoCAD I ARC 308: Introduction to AutoCAD II ARC 407: AutoCAD Workshop Practice I ARC 408: AutoCAD Workshop Practice II ARC 816: Advanced AutoCAD Presentation and Practice (M.Arch)
University of Jos, Jos	CS 101: Introduction to the Use of Computers CS 201: Introduction to the Use of Computers ARC 471: AutoCAD

Source: Field studies.

5. Computer Curriculum of Selected Foreign Schools of Architecture

The use of computers in architectural education in foreign schools is as varied as the philosophies and technological level of these schools. The older schools tend to retain traditional architectural design techniques while gradually introducing computer usage. The more modern schools, especially those in Universities of Technology tend to emphasize and encourage computer usage. However, the Architecture Department of the Kwame Nkrumah University of Science and Technology does not offer purely computer courses in its curriculum (KNUST web site, 2006).

5.1 Computer Courses in the Architecture Curriculum of Massachusetts Institute of Technology, Cambridge, USA

The Department of Architecture of the MIT School of Architecture and Planning offers two degree programmes for undergraduates: The Bachelor of Science (BS) and the Bachelor of Science in Art and Design (BSAD). The BSAD includes several different undergraduate fields, not just in architecture but in the arts as well. The Institute runs a course credit system, and students are required to choose relevant courses to make up the number of credits required for graduation which is 180 units. The computer courses carry 9 to 12 credit units. The computer courses offered in the architecture curriculum are described in table 5. Apart from these courses, computing is integrated into all design studios. New students are assumed to be proficient in general computer usage before admission.

Table 5: Computer Courses in the Architecture Curriculum of Massachusetts Institute of Technology, Cambridge, USA

Course Code and title	Course description
4.500 Introduction to Design Computing	Introduces students to architectural design and computation through the use of computer modelling, rendering, and digital fabrication. Students design a small building using computer models leading to a full package of physical and virtual materials, from computer generated drawings to rapid, prototyped models.
4.501 Architectural Construction and Computation	Investigates the use of computers in architectural design and construction. Begins with a pre-prepared computer model, which is used for testing and process investigation in construction.
4.510 Digital Design Fabrication	Introductory subject in advanced computing, rapid prototyping, and CAD/CAM fabrication for architects.
4.511 Digital Mock-Up Workshop	Advanced subject in computer modelling and CAD CAM fabrication in building large-scale prototypes and digital mock-ups within a classroom setting.
4.512 Special Projects in Architectural Digital Fabrication	Individual research or project team work with digital fabrication software and devices in the computational design process.
4.513 Special Problems in Digital Fabrication	Supplementary work in advancing understanding of digital fabrication software and devices in the computational design process.
4.520, 4.521 Computational Design I: Theory and Applications	Introduces design as a computational enterprise in which rules are developed to compose and describe architectural and other designs. Topics include shapes, shape arithmetic, symmetry, spatial relations, shape computations, and shape grammars.

Course Code and title	Course description
4.522, 4.523 Computational Design II: Theory and Applications	Introduces advanced topics in shape grammar theory and applications. Discusses generalizations of the shape grammar formalism that permit greater flexibility in computing designs. These include parametric grammars and parametric design, parallel grammars, and colour grammars.
4.540, 4.541 Introduction to Shape Grammars I	An in-depth introduction to shape grammars and their applications in architecture and related areas of design.
4.542 Background to Shape Grammars	An advanced examination of the shape grammar formalism and its relationship to some key issues in a variety of other fields, including art and design, philosophy, history and philosophy of science, linguistics and psychology, literature and literary studies, logic and mathematics, and artificial intelligence.
4.543 Special Problems in Shape Grammars	An opportunity to use shape grammars or related algorithmic devices to characterize detailed designs in a historical corpus or original designs conceived from scratch.
4.560 Geometric Modelling	Introduces the fundamentals of three-dimensional geometric modelling and associated computer-aided design as well as visualization applications in architecture, urban design, and computer graphics production.
4.562 Architecture in Motion Graphics	Provides an opportunity to undertake advanced projects in architectural visualization with an emphasis on the use of computer graphics animation and video production media.
4.564 Formal Design Knowledge and Programmed Constructs	Provides practical and theoretical foundations to explore computational issues relevant to representation of architectural forms and design knowledge.
4.566 Advanced Projects in Digital Media	Develop independent projects in the study of digital media as it relates to architectural design.
4.580 Inquiry into Computation and Design	Explores the varied nature and practice of computation in design.
4.581 Proseminar in Computation	Introduction to traditions of research in design and computation scholarship. Different computational approaches for understanding and thinking about design, and for doing design, are introduced.
4.582 Research Seminar in Computation	In-depth presentations of current research in design and computation.
4.590, 4.591, 4.592, 4.593 Special Problems in Architectural Computation	Opportunity for individual or group pursuit of topics not covered by regular Computation offerings.
4.594, 4.595 Workshop in Architectural Computation	Opportunity for group exploration of a special topic in computation through research-focused design projects or exercises.

Source: http://web.mit.edu/catalogue/degre.archi.ch4.shtml

5.2 Computer Courses in the Architecture Curriculum of University of Cambridge, Cambridge, UK

The Department takes the view that all students should acquire computer aided design skills as an integral part of their architectural training. The links between CAD teaching and studio work are strong: by the end of the undergraduate course many students are making extensive use of the Department's CAD facilities for their projects. The Computer Aided Design course introduces students to the basic principles of the architectural use of computers in the First Year and by the end of the Third Year students will have had specific training in a number of CAD applications (University of Cambridge, 2005).

The Aims of the Course

Over the three years of the undergraduate course, CAD teaching in the Department aims to:

- give the students a general overview of the general principles of CAD and IT in Architecture;
- teach the principles of 2D and 3D techniques and apply them to studio work;
- integrate scanning/photographic techniques with the 2D/3D digital environment;
- learn to work in a mixed environment, moving between digital and traditional techniques.

Learning Outcomes

By the end of the third year of the undergraduate course students would have:

- learnt to evaluate the potential and limitations of digital tools in the field of Architecture;
- learnt to develop a good knowledge of the use of digital tools and acquired a 'digital craft' specifically applied to the field of Architecture;
- acquired experience of integrating digital and traditional techniques in the production of a portfolio;
- learnt to produce working drawings in the CAD environment as training for the year out.

6. Proposed Computer Curriculum for Nigerian Schools of Architecture

It is proposed that Schools of Architecture upgrade their curriculum to include some or all of the following courses (Table 6). Obviously, nomenclature and course content may vary from school to school.

Table 6: Proposed curriculum for Schools of Architecture

Level	1st Semester	2nd Semester
100	Introduction to Basic Computing	Computer Graphics in Architecture
200	Introduction to CAD	Integration into 200L Studio Project Elective
300	Introduction to 2D CAD for Architecture	Integration into 300L Studio Project Elective
400	Introduction to 3D CAD for Architecture	Integration into 400L Studio Project / ITF Elective
500	Visualisation and Animation in Architecture	Integration into final year project

The following course descriptions are proposed.

6.1 Introduction to Basic Computing

Computer appreciation: basics and history of computing, including familiarisation with the hardware and software. Operating systems: Microsoft Windows and other operating systems. Internet Appreciation: The World Wide Web, email, chat rooms, search engines and directories. Application packages including *Microsoft Word, Microsoft Excel, Microsoft Access* and *Microsoft PowerPoint*.

6.2 Computer Graphics in Architecture

Proficiency in the use of graphics software such as *Adobe PageMaker, Adobe PhotoShop, Corel Draw!, Corel Photo Paint, Harvard Graphics, Micrografx Designer, MicroGrafx Picture Publisher, Microsoft Paint, Microsoft Power Point* and *Microsoft Publisher*

6.3 Introduction to CAD

CAD concepts and theory including layers, blocks, arrays, colours, linetypes, lineweights, text and dimension styles, coordinate systems, relative and absolute coordinates, layouts, paper space, model space, views, viewports, plotting, hatching, dimensioning, object selection, object properties, object snap, lighting, materials, panning, zooming and orbiting.

6.4 Introduction to 2D CAD for Architecture

Proficiency in two-dimensional (2D) Computer Aided Draughting includes the ability to independently produce basic drawings such as plans, elevations, sections, details and schedules at a professional level. Layouts and plotting. Mastering CAD software such as AutoCAD is essential.

6.5 Introduction to 3D CAD for Architecture

Production of 3D architectural models using AutoCAD, ArchiCAD and Autodesk Architectural Desktop. Creation of basic 3D geometry. Projection of 3D models from 2D floor plans using AEC objects for creation of walls, doors, windows, roofs, etc. Layouts and plotting. Mastering CAD software such as AutoCAD, ArchiCAD and Autodesk Architectural Desktop is essential

6.6 Visualisation and Animation in Architecture

Production of life-size and detailed models of buildings and complexes using advanced techniques including daylighting, artificial lighting, materials and landscape elements such as plants, people, animals and vehicles. Students should be able to produce photo-realistic renderings and animations at a professional level (Ogunsote and Prucnal-Ogunsote, 2005).

6.7 Electives

Electives should include courses that enhance proficiency in specific software. Recommended electives include the following:

- Mastering CorelDraw!
- Mastering Microsoft Publisher
- Introduction to AutoCAD
- Advanced AutoCAD
- Introduction to ArchiCAD
- Advanced ArchiCAD
- Mastering 3D Studio Max

7. Integration into Studio Projects and Practical Courses

All students should be required to use CAD for their projects after a certain level. The teaching of several concepts and software packages can also be made the responsibility of studio lecturers. This will help bring back the culture of working in the studio, while making the addition of many new courses to the curriculum unnecessary. The studio course content should simply be modified to include the necessary CAD components. The CAD components that should be integrated into studio projects and practical courses are shown in table 7. Students should be encouraged to submit assignments and research projects in digital format.

Table 7: Integration of CAD into Studio Projects and Practical Courses.

Course	Integrated CAD Components
Graphic Communication	Assignments using Microsoft Powerpoint, Corel Draw!, etc.
Architectural Graphics	Assignments using Corel Draw!, 2D CAD, etc.
Presentation Techniques	Assignments using Microsoft Powerpoint, Corel Draw!, etc.
Building Components and Methods	Assignment: simple drawing using 2D CAD
200L Architectural Design Studio	Assignment: simple drawing using 2D CAD.
300L Architectural Design Studio	Presentation of selected portion of design using 2D CAD.
400L Architectural Design Studio	Presentation of selected portion of design using 3D CAD.
500L Architectural Design Studio	Presentation of selected portion of design using 3D CAD.
Final Year Project	Production of part of final year project using CAD.

8. Implementation Strategies

8.1 Facilities Required

Ogunsote (1989, 2001a) deliberated upon the setting up of a workshop for Computer Aided Design and Draughting. Facilities and equipment required include computer hardware, computer software, power supply and lighting, trunking and cabling, networking, furniture and furnishing, audio visual aids, library, internet connectivity and security.

8.2 Maintenance

Computer equipment can quickly develop problems, especially when used by a large number of people and for long periods. It is important to have good and prompt maintenance of all computer equipment. This is best achieved by employing an in-house engineer for regular maintenance, although complex repairs may be best handled by a central maintenance workshop.

8.3 Funding

The funding of CAD proficiency must necessarily be shared by all the stakeholders. Even when computers are bought through special grants or donations, they still need to

be maintained and upgraded. A way out is to charge students a CAD fee per semester. The amount charged should be adequate to supplement what is available, and will necessarily vary from institution to institution. A possible scenario for funding CAD proficiency is presented in Table 8 below.

Table 8: A possible scenario for funding CAD proficiency

Cost Centre	Funding
Initial setup of computer workshop or laboratory including premises, furniture, computer equipment, printers and plotters, power equipment, power generator, networking, air conditioning, et cetera.	The institution should have the largest share, though this can be done through donors to the institution.
Maintenance, upgrading and refurbishment	This should be financed by students through laboratory fees
Consumables such as paper and cartridges	This should be financed by students through laboratory fees
Computer equipment in each student's room	Students
Computer equipment in each staff office	Staff with support from the institution

8.4 Role of Professional Bodies and the National Universities Commission

Professional bodies such as the Nigerian Institute of Architects should make CAD proficiency a condition for accreditation and demand that tertiary institutions provide the facilities required for CAD literacy or be denied accreditation. Graduates submitting log books for professional examinations should also be required to mandatorily include CAD-based projects.

The Minimum Academic Standard (MAS) recommended by the National Universities Commission should be revised to make it mandatory for architecture students to become proficient in Computer Aided Design before graduation.

9. Conclusion

Several schools of architecture already have large computer laboratories, while practically all schools have computers. The problem of CAD illiteracy in lecturers is also gradually becoming a thing of the past with most lecturers now having their own computers. Even students have started buying their own computers. The authors strongly believe that now is the time to integrate CAD proficiency into the architecture curriculum, thus making CAD proficiency a condition for graduation of architects. This will involve high initial investment and high running costs, but this is still within the level found in several private secondary schools in the country. Focused action by heads of schools of architecture can achieve the transformation needed within a few years.

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The postgraduate programmes in Architecture have been structured to produce highly skilled architects capable of facing a broad spectrum of challenges in environmental design in Nigeria, in particular, and with adequate professional knowledge of the global situation in general. OBJECTIVES: The programmes, therefore, seek to develop, through research, economical and efficient means and methods of building within the social, Physical, and cultural context. The student is expected to be conversant with research in decision theory, human behaviour patterns and perception, building science and tech Anatomy is the scientific study of the structure of organisms including their systems, organs and tissues. It includes the appearance and position of the various parts, the materials from which they are composed, their locations and their relationships with other parts. Anatomy is quite distinct from physiology and biochemistry, which deal respectively with the functions of those parts and the chemical processes involved. For example, an anatomist is concerned with the shape, size, position, structure, blood supply and innervation of an organ such as the liver; while a physiologist is interest