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Digital Permeations in Architectural Design Studios

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ABSTRACT

Design is a tangible expression of the designer's visualization in response to the end-user's needs, desires and expectations. A no. of toolsets enable the initial sketch scribbled as a component of design development process to shape up as an iconic product. The more a designer sketches, the better is the refinement of the iterations. The first revolution in in the history of communication, happened with the help of rock carvings or graffiti. As crafts evolved, a legacy of creativity emerged. Skilled masters took on apprentices under their flagship. The latter would blend the former's legacy with their own creative instincts while executing a project. This tradition continued till the invention of paper and pencil. Different varieties of paper offered the documentation of the projects in different styles of drawings. The era of "Graphics" had arrived as a breath of fresh air. Calligraphy and development of perspective drawing, supported the cause of "Thinking Design". The designers gained universally, as 'a recognized professional community'. Industrialization brought in the printing mechanism, with the result that multiple copies could be easily reproduced and circulated widely. The designers involved in design development, hailed the printers as allies to the deliberations and consequent improvements.

Change has always been an inevitable part of growth. The advent of computers has furthered the morphogenetic, generative and communicative features of Design. The designers are capable of delivering a holistic project while iterating the multilayered sheet-sets amongst the Architectural, Engineering and Construction (AEC) collaborators and also with the clients. Immersive Virtual Reality is adding a new dimension to visualization of a project from inside to outside. Computerised Automatic Virtual Environment (CAVE) labs are opening up unbounded possibilities in which every single element can be conceived in detail. This paper presents an analytical view of the methods of Design Thinking and the scope of Virtual paradigms. It also brings the digital explorations to the fore, the indulgence of Design Studio and the rigor of the pedagogical arguments within the design inquiries.

KEYWORDS: DESIGN, ITERATIONS, DOCUMENTATION, VIRTUAL REALITY, CAVE SYSTEMS

INTRODUCTION

Ever since the existence of the humans, the communication techniques have been under constant evolution. The sign language, graffiti, and visual arts- all these modes, displayed the normal intelligence of the then people to adapt the environment to their own needs. Early cave paintings depicted the day to day activities, the relationships amongst the people and with the deities. The folk arts and crafts, created with natural dyes (procured from vegetation) were secured from the vagaries of weather in these caves. As such the caves offered shelter to the all the species including man. As civilizations progressed, the visual aids took centre stage in the Design process. viz; sketching developed as a tool to express the fluency of thoughts. Intuition and perception enabled the development of problem solving process through scribbled sketches. The sketches supported experimentation with materials and a new paradigm of expression emerged. However the entire activity was limited to Crafts, even shelters were designed and developed by the master craftsmen who banked on their own memory sketches, individual reasoning skills and judgment. The representation of mental images led to the evolution of Form based Designs. The master craftsmen developed designs with multi-disciplinary skills in drawing and sculpting. The early construction activity evolved as sculptural assemblage

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of materials and techniques. The so-called designers imbibed ideas from mother nature and developed them into forms. They preserved their values in the shape of carvings and embellishments, very laboriously. They drew upon the surroundings and invented calligraphy sets chiseled out of wood, stone, etc. Their intentions to document their works have been illustrated in the early scriptures as old as 3 BC; inscribed in collections of palm leaves, birch barks, silk, cotton etc. Dr S M Vaidya and Dr Pratibha V Kulkarni[1], in their extensive research on the manuscripts of ancient India, have highlighted the intellectual wealth of India. According to them, widespread epigraphic activities were taken up with the following materials while use of paper is traced back to the arrivals of the Moguls in India (816AD):-

WRITING AND DRAWING MATERIALS	SURFACE MATERIALS
Kalma/Lekhani/ Lohakantaka - stylus or pen	Patra – leaves
Kajjala/ Masi - ink	TathaaKaagalam -paper
Kumpi - ink pot	Palm leaf -tala patra
Kesha - hair	Bhoorjapatra - birch bark
Madhyeca shubhram kuSham -grass tied in middle finger	shilalekha - Rock edits
Balu - reed pen made up of bamboo	tamrapatra - Inscriptions on copper plate
Kambi - linear marker	Conch shell - mother of pearls
Prakara /Jujavala - compass	Skin of elephant
Kalmadaana - compass box	Phalaka - wooden plank
KRupaaNikaa-knife	Skin of bamboo
Kattari -scissor	Sanchipath
Dora – cord (binding surface)	Bhitti - surface conaitining paintings
Varnaka -coloured stick, usually white like a pencil used to draw on a board.	KaashTa - wooden platform
Khatini - chalk	
Manashilawas - soft stone for writing	
Varnavartika - coloured pencil	
Kunchika - paint brush	
Vartikakaranda - painter's box	
Aksharabhoomika -tablet/board	
Kambi - ruler	

1: Vaidya S M ,Kulkarni Pratibha V ; "Writing In Ancient India And Writing Materials - In The Study Of Manuscripts" ; International Journal of Innovative Research and Advanced Studies (IJIRAS) Volume 3 Issue 10, September 2016. ISSN: 2394-4404

Earliest known architect's drawing, depicting the

The beautiful carvings of two Buddhas- Prabhutaratna

ground plan of the palace of Nur Adad in Larsa.Clay tablet engraving; 1865-1850 BC . Image Source: Grisinger Gordon, http://www.payette.com/posts-by-author/601531-gordon-grisinger

& Sakyamuni, flanking a stupa. –. Photo courtesy of Harald Hauptmann / Heidelberg Academy of Sciences and Humanities, Germany

Image Source: https://edmortimer.wordpress.com/2011/06/11/ & https://www.wmf.org/project/petroglyphs-diamer-basha-dam-area

The most notable fact is the peoples' willingness to accept 'change'. Change spelled development. The erstwhile craftsmen and the sculptors recognised the mode of transfer of knowledge in mentor-mentee system. As time evolved, ' Architecture' emerged as the profession of the building industry. The architects accepted 'Design Cognition' as a mainstream event in the phenomenon of design development.

DESIGN COGNITION

The development of spatial models from mental images is a complex process in itself. The visual aids that help yield the final product are 'thinking, drawing & modeling'. To a designer, the hands are the translators or the manipulators. The hand and mind synchronization is the most vital element of a good design. Any imbiguity in interpretting whatever goes on in the mind, enables creativity. The potential of the hand gestures, be it on paper, materials- in- situ, in the lab or the board room; leaves immense impression on the final outcome of the evolutionary stage. Generating a design follows the binomial solutions to any given situation, very artistic but in a scientific temper. Design development in each project has to go through a set of exercises. viz; the literature study, the case studies, the site analysis, preliminary discussions, modelling, expected outcomes, project planning and management and post occupancy evaluations. Each step is iterative and the design swings back and forth till a final solution is acceptable to all the teams involved. All the team members share a common goal of building a project, right from planning to final execution. In order to deliver the best, the academics hold a much greater responsibility of synchronizing with the advancements in the allied disciplines. Each discipline is involved in the Research and Development exercises, aimed at building a better environment. Designing the Design, entails information from the collaborators in simulated environments. Simulation catalyses analysis. Analysis aids improvements in planning as well as execution. The final outcome, thus achieved, is more livable.

THE ADVENT OF COMPUTERS

Nowadays the practice of Architecture is an in-house facility where all the artists, engineers, model makers, project managers and evaluators work in unison. Each one of the associates is accountable to the final product. The arrival of computers has simplified the sharing process and simultaneous revisions incurred in the product. The concurrent revisions take shape and effect automatically. An Architect has many options available to develop the design on the screen. The context of scale and size is easily manageable with the help of cross referencing between the layers. Drawings can be easily imported from one platform to another. Graphic User Interface has further eased out the application of the softwares. However, the users find themselves in a fix when encountered with any problem regarding connectivity or the issues related to the softwares.

Architects are trained to the inbuilt system of design development through the various stages of its progress. If these stages are analysed, then the sequence can be equated with Algorithms. An algorithm is the flow-chart of the step-wise process. An Architect can Program his Design and let it develop through the iterations. Universities all over the world have taken note of the impending need to include computers in the core curriculum.

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Glenn Goldman and Andrzej Zarzycki of New Jersey Institute of Technology, have outlined the accreditation requirements of NAAB and NCARB in their paper[2] on framing curriculum for Architecture and Interior Design courses. Their findings conclude as below:

" As both interior designers and architects have increased concern about, and responsibility for, sustainability (as well as LEED certification for projects), computational tools that include graphic representations of data that have few equivalents in traditional media become more important". Students have to be encouraged to include feedbacks of simulation data into their Design projects.

They have proposed 'Advanced Option Studios' to upper level students to enable them produce comprehensive products in collaboration with allied subjects. The course curricula of different institutions as analysed are:

NAME OF INSTITUTE	CORE SUBJECTS
Massachusetts Institute of Technology	*Design and Construction* integrated with *Architectural Computing*;
	Scripting Codes to produce Graphic Solutions;
	Digital Editing Techniques to render visual effects in *Advanced Video*

2: Glenn Goldman and Andrzej Zarzycki, New Jersey Institute of Technology; "Digital Media in Architecture and Interior Design - Curriculum Framework Report for the Siggraph Education Committee", Version 0.2, April, 2010

New Jersey Institute of Technology	Graphics: Vector & Raster; as a communication tool for Design
	Discreet Simulation studios collaborated with design decisions
	Digital Tectonics and BIM to conduct in-studio spatial and virtual analysis as a part of energy-conscious Architecture
	Cinematic Literacy to inculcate expressive communication skills in print and digital media alike
University of Southern California	Amalgamation of Digital Animation, Geometric Modelling for planning and executing first hand demonstrations of live projects
University of Pennsylvania	Digital Media, Animation, Cinematography and Interactive Multimedia together constitute the Design studios
Virginia Tech	Vector modeling, light simulation, digital imaging, and data exchange all are taught as a basic parameters for a comprehensive design project
	Media constitutes an eminent part of Environment Workshop
University of California – Berkeley	Computing Techniques, rendering and compositing are a pre-requisite to design development
Iowa State University	computer taken as a design and manufacturing tool- laser cutting, 3-D printing and CNC routing
Yale	CAD/CAM workshops lead from traditional fabrication to digital mode
Rhode Island School of Design	Computational Environments to critically test the materializing space
	Cinema 4-D integrated with the course contents
Art Institute of Chicago	Trans-disciplinary design studios to yield interactive environments for students and industry

Further to this research, the author analyzed more institutes as below:

Rhode Island School of Design	Envisages Iterative Computations as a challenge to the base conceptions of Design and Architecture. Works of Design computation theorists and researchers (Knight, McCullough, Mitchell, Negroponte, Stiny, and others) as well related architectural, artistic, philosophical, and epistemological positions (Dewey, Evans, Klee, Lynn, Petherbridge, Schon, and others).
Carnegie Mellon University	Digital drafting, construction drawings, advanced 3D modeling and HTML programming are the elements of Analog Studio. Digital Tooling is based on the idea that pushing the limits of design fabrication; comes from knowing the limits of your tools. Digital fabrication helps break these limits and put laser cutters & 3 D printers to use. In Scripting and Parametric Design, students use algorithmic logic to prepare their own Grasshopper components.

Virtual Classrooms aid teaching online to students located at more than one point. The advent of digital platforms like Activeworlds, Adobe Atmosphere, Second Life, etc., has enabled virtual spatial experiences to students . They can reiterate their experiences while designing, in the architectural design studio.

INTEGRATING BIM WITH ARCHITECTURAL DESIGN:

Arno Schlueter and Frank Thesseling of the Swiss Federal Institute of Technology; have conducted a workshop on Parametric Modeling in Building Design. Their workshops conducted for retrofitting the European buildings aimed at developing an understanding of Form, Materials and Technical Systems at early design stages. Design Performance Viewer and Autodesk Revit were integrated to link the performance and progress of Design. They have summarized their findings in a paper, *"Balancing Design and Performance in Building Retrofitting: A Case Study Based on Parametric Modeling"*; and have stated that the onus is on the educators to teach integrated design and parameters, concepts and tools to the students lest they should struggle while adapting to such a different strategy at later stages in practice.

Architects Sean Ronnie Hill and Alejandro Vega of RISE Design Studio, London use BIM X Hyper-model Software from Graphisoft, to allow users to have Building Information Models into the dynamic touchscreen environment of their mobile devices.

Simulation and Modelling enables the designers to improve energy rating of the projects and analyse the selection of optimum materials right through the design process. At the outset, any project can be quantified and developed to perform better with respect to climate and weatherability. Performance analysis takes on many different hats. viz;

I.	Sketch Design Stage	Inception of Design Idea, Structural integrity, energy efficiency, comfort & costs.
II.	Pre-Design Stage	Developing form and spatial characteristics, structural stability & Sustainability
III.	Final Design Stage	Analyzing , calculating the dimensions, materials, structural details, Specifications, sequences and buildability.

The building's physical quantities that can be predicted/measured/controlled – all constitute the performance analysis. Investigating a problem and the requirements is termed as Requirement Analysis, and investigating the domain of the objects is referred to as Object- oriented Analysis. If the conceptual solutions constitute Design, then the collaboration of software objects lead to Object-oriented Design.

The **performance** can be ajudged in the following models:

Waterfall Process Model:	Sequential development approach with development taking place steadily down the algorithm/program like a waterfall
Iterative Model:	The entire program when divided into logical steps and the feedback from each step is clubbed with the requirements of the next step; such repetitive steps/iterations act like a mini waterfall.
Spiral Model:	It is a meta-model. Each cycle goes through same sequence of steps to identify objectives , develop alternatives to risks observed, verify the iterations and plan for the next cycle simultaneously keeping the costs and client perspectives in view.

William J. Carpenter in his book, "Learning by Building: Design and Construction in Architectural Education", has expressed that the Latin word *'Architectus'* is derived from Greek word 'archi' (a person of authority) and '*tekton*' (a builder or craftsman or fabricator). The best International firms have in-house services which look after the entire design development process; as quoted by the Architects of Foster+Partners[3]:

"To undertake some of the largest and most complex projects in the world needs depth of resources. We continue to develop our range of skills and capabilities in order to provide a

comprehensive end to end design service to our clients. Our team have access to a variety of

cutting edge support services including model shops, library and a dedicated materials research centre, as well as the latest CAD and BIM software".

BIM is nowadays being promoted as a common platform for sharing information between the collaborators. However, there is a wide gap between the application of BIM in early design stages and analysis. Architects who are responsible for design do not have either the information or the expertise on simulation software tools. Numerous debates on stage at which BIM should be included have been taking place. viz; Holzer(2007), questions-

"how far down the track in the design process should we start using BIM? Can a single BIM model assist in the design process from early design stage to operations?"

Schlueter, et al have discussed the missing co-ordination between the tools and their users, right from concept stage to the final operation, which affects the efficiency of facility management adversely.

3: "http://www.fosterandpartnerscareers.com/working-here.asp#sthash.zGjqobqy.dpuf"

Others like *Coates, et al 2010;* Hartmann et al, 2008;and 2009 have questioned the lack of simplicity with BIM which exists naturally with the traditional methods of pencil and paper while working out alternative solutions.

ROLE OF SCRIPTING LANGUAGES

A Script is the theme along which the final storyline develops. The Graphical User Interface of the softwares depends upon interpretable programming languages or Scripts. Any computer language can be written as a Code or a Script to be run. Open Source Scripting languages like 'Processing' are gaining popularity because of their visual compatibility to even novice programmers, amongst the Architectural fraternity. Scripting languages in use with Architectural softwares are:

ARCHITECTURAL SOFTWARES	SCRIPTING LANGUAGES
Autocad	Lisp, AutoLisp
3DS Max	Maxscript
Autodesk Revit	Revit, python, shell

Rhinoceros	Rhinoscript (based on VBScript) and Python (V5.0+& Mac) + plug-in: Grasshopper
BIM	LENA & VisualARQ

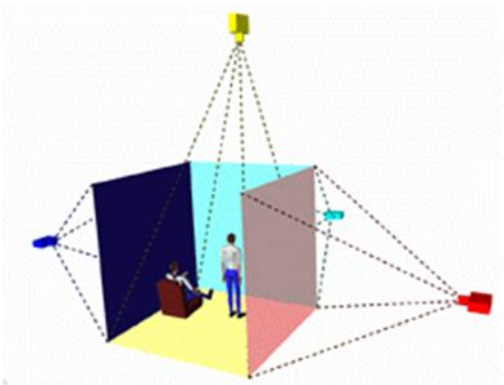
Learning Scripting languages can enable a student to understand the harmonics of shapes and volumes in design development and hence put visual programming to use as a medium for iterative and factorial developments.

Mark Collins and Toru Hassegawa[4] of GSAPP, Columbia University, have integrated Advanced Algorithmic Design with Architectural curriculum. Their vision is that the combined teachings of Object Oriented Programming and Processing will prepare the young architects model complex systems and have III[rd] party libraries (i.e. for interacting with Kinect, GIS, video, mesh generation)".

VIRTUAL DESIGN AND CONSTRUCTION PRACTICES:

In $1930_{s,}$ Architect Le Corbusier said, " A building is a machine to live in". Accordingly, new technologies are adding a new dimension to Design with tools.

TOOLS NEEDED TO SUPPORT:	SOFTWARES & PLUG-INS	TYPOLOGY OF STUDIOS
o Sketch Recognition o Speech Processing o Desktop Virtual Reality (VR): simulated scenes o Augmented Reality (AR): recognition of physical world with computer vision o Mixed Reality: VR + AR o Computerised Automatic Virtual Environment (CAVE)	o Sketchup: Gamewave o Grasshopper & Rhino 3D : Firefly o Tab-sketch: Tablet PC & Sketchbook Pro o VR Sketchpad	o CAD Studio: softwares tending to conventional studios o Cad Plus Studio: integrated CAD knowledge in Design o Virtual & Web Design Studio: collaborations on web o Cyberspace Design Studio: inegrate Virtual and physical Communities o Intelligent Building Studio: embedding computation to built environment o Tools & Toys Studio: experiments design media for tools of future



CAVE Environment by K.-P. Beier, Image Source: http://www.umich.edu/~vrl/intro

VR simulation projects of the medical clinic redesign; Image Source: Antonieta Angulo,

CONCLUSION:

Our society aspires to improve its endeavor and to utilize its resources in more generative ways. Technology is putting in its contribution, to provide such an environment. Digital tools are under review as conceptual aids that help break away the traditional process of design development. Globally the pedagogical role of the programming languages is increasingly being experimented with. Students are being exposed to the scripting codes in the same way as they would learn grammar and its syntax. Emphasis is being laid on the factorial analysis of complex forms. Functional performance of the materials needs to be tested rigorously in simulated environments. As such, more number of students from the industry can be encouraged to take up the advanced studies and discuss their evaluations.

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