RESHAPING PEDAGOGY IN ARCHITECTURAL EDUCATION FOR THE INFORMATION AGE

by

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A Thesis Submitted to the Faculty of the

COLLEGE OF ARCHITECTURE

In Partial Fulfillment of the Requirements

for the Degree of

MASTERS OF ARCHITECTURE

In the Graduate College

THE UNIVERSITY OF ARIZONA

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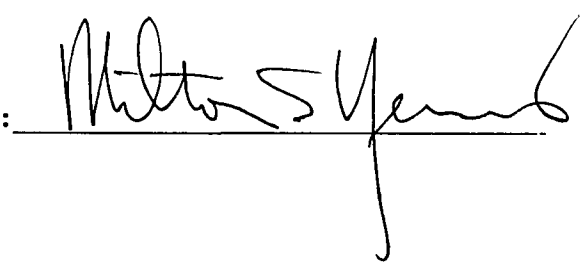
SIGNED: 

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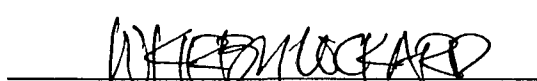

W. Kirby Lockard
Professor of Architecture

4/14/95
Date

ACKNOWLEDGEMENTS:

Once after the end of a term, in my life as a professor, I received a note from a student thanking me for allowing him to "do what the hell he wanted to do" during the process of producing a very successful undergraduate design thesis project. I was puzzled by this message for a while since I didn't consider that to be much of a contribution. Later I came to understand that this student was thanking me for trusting him to exercise autonomy.

I am at a point where I could write the same note to the entire College of Architecture, University of Arizona especially my graduate committee and those individuals to whom I sought advice. I too have been granted to privilege of proceeding on my own terms with much guidance and encouragement along the way.

My Graduate Committee consisting of Chair Professor Kirby Lockard, Professor Oscar Blazquez and Professor Bill Stamm, have been patient and willing to allow me latitude to pursue this critique of architectural education. Thank you all for the time, criticism, and suggestions many of which you will find incorporated within this document.

Thank you, Professor Lockard for sharing with me your vast understanding of design communication and shedding light on issues of attitude and acceptance.

Thank you, Professor Blazquez for the perspective which you brought regarding empowerment and computer instruction.

Thank you, Professor Stamm, for opening those important connections between academia and practice, between traditional means and digital means I have termed "fusion".

I would also like to acknowledge Associate Dean Linda Sanders, for the time and encouragement she was able to gave from her busy schedule, Professor Brooks Jeffrey for his ever present ear when I had a problem, question or gripe, and Professor Carl Rald for the critiques he gave and his valuable insights on education.

Beyond this institution, there are many who have given encouragement and support. Thanks to those at North Dakota State University Administration, the College of Engineering and Architecture who helped initiate my Developmental Leave, and all my colleagues back at the Department of Architecture and Landscape Architecture. Finally I have been blessed with the special understanding of family and friends who were there when I called (which I did a lot of). My Tucson experience has also given me the opportunity develop many new friendships and by being here for me, they too have also contributed. I would like to especially thank MS Barbara Geary for her generous assistance in proofreading this document but in fairness to her, I have continued to meddle unceasingly.

DEDICATION:

I am dedicating this thesis to my wife Barbara and daughter Molly. It took faith, love, and courage to let this separation take place but it took work, determination, and patience to carry on while it was happening.

Thank you, I love you both!

TABLE OF CONTENTS:

ABSTRACT

Digital technology was introduced to architectural practice during the last decade. Traditional techniques have developed along with practice for thousands of years. There has been hesitation to adopt this new technology, on the part of academia, due to ideological resistance and limited resources. Practice, out of necessity, adopted computer technology but has not developed its full potential.

This thesis investigates reshaping traditional architecture school curriculum to include networked computers and peripherals. This is a process most architecture schools must soon face. Precepts are formulated to assure freedom and autonomy prevail in the transitional confusion. The Curriculum will be transformed to take advantage of what digital means and information technology have to offer while maintaining continuing to support of traditional means. Fusion between traditional and digital means, will foster a climate which will spawn creativity and innovation. A foundation course illustrates an Information Age approach to teaching design communication.

CHAPTER ONE

Architectural education and practice are both confronting the Information Age by virtue of the digital computer. The document you are about to read investigates past and present manifestations of the Information Age on architecture and speculates on a future from an educational perspective.

Chapter One is devoted to systematically identifying the problem from the perspective of architectural education. It also establishes a set of "marching orders" to guide research and develop problem solving strategies.

Chapter Two provides necessary background to understand the Information Age, reviews the mission of the architectural profession, tracks the establishment of traditional means of practice, assesses the results of deployment of digital means, and determines what role if any, architecture schools played in the process.

Since it is a foregone conclusion that something must happen, it is up to the institution itself to determine how it will proceed. Chapter Three establishes precepts for dealing with issues which cut through technological hype to reconsider the worth of the individual. Destructive attitudes and actions directly related to this paradigm shift are challenged and replaced by positive constructive ones. Perhaps something akin to affirmative action is necessary to address injustice grown from ignorance within the profession and academia.

Chapter Four begins reshaping pedagogy guided by goals and

tempered by precepts. Here the large issues of curriculum, faculty and students are addressed.

Finally, Chapter Five elaborates on the specific manifestations of pedagogical reshaping. It reviews the pragmatic decisions which come with the digital territory, details coursework and speculates on sites virtual architecture schools in Cyberspace.

Although what is included may prove to be adequate as a guide, individual institutions must take ownership of this reshaping process in the same way as faculty and students must take ownership of the computer. Only through this "ownership" will those institutions and the individuals involved be able to make decisions which are suited to their needs.

Problem and Sub-problems:

This thesis addresses reshaping architecture school curricula by proposing goals and objectives followed by policies and applications which acknowledge and exploit the digital means and information technology in the profession of architecture. Implementing such a curriculum depends on computer empowerment, since computers cannot be taken seriously if they aren't accessible to the same degree as the parallel bar, triangle and pencil. In the context of this thesis, the word empowerment implies the enabling students access to computers.

Such empowerment initiatives demand a leap of faith by their sponsors. Architecture schools owe a debt of gratitude

to Michael Berk and his colleagues from Mississippi State's School of Architecture for their pioneering, prototypical effort to empower students with computers. This has given others the courage to make proposals of their own. The two unique issues which rise to the top of Mississippi State's effort were the purchase of computers by students, assuring that hardware would always be current, and the fact that these computers were of the compact "lap top" variety, allowing flexibility within a studio setting and the continuation of traditional means.

Presently, limited resources plague most schools and as a consequence, students have received limited exposure to computers. Graduates leave academia with few skills and little conceptual understanding of computers when compared to the strong emphasis usually afforded design and other issues of practice.

Professionals, left unguided by academia, made highly pragmatic decisions based on the narrowest of criteria in purchasing and administrating computer systems. These computer systems are utilized only for digital means analogous to traditional means used prior to computerization. Architecture hasn't capitalized on computer-centered innovations used by other sectors of society in areas of communications and information technology.

In the face of this transition, students, faculty, the facility and the course work(basically the entire program) each require evaluation and modification. Students have little or no hesitation to embrace technology but exhibit a

tendency to literally adopt the same limited, pragmatic view as the profession.

Stereo typically overworked and underpaid professors may agree in principle with adopting computer technology into their curriculum but do not take kindly to change and the added responsibility of initiating it. Faculty who are not inclined to be comforted by computers find the notion of digital relevancy distasteful. Graduating students, on the other hand, are not afforded the privilege of academic freedom; they have no choice of whether or not to use the computer in the workplace. Those principals conducting job interviews even advertise and make an issue about ability to use the industry standard hardware and software (a feat most of them haven't conquered themselves). Situations like this arise from fear and insecurity due to a lack of knowledge and point right back to architecture schools.

Connectivity, power supplies, proximity, security, input and output devices all challenge budgets and stress facilities already being used "too creatively". Placing and paying for network infrastructure where it previously had not been needed bewilders the issue further.

Crafting digitally relevant courses will add content to curriculums already bulging with mandated requirements. What existing content can be dropped or where do the new credits come from? The certainty of continuing technological innovation presents the problem of maintaining vitality and flexibility at the expense of stability.

An issue which underlies any discussion of digital design

is that of actually using digital means for conceptual design. A vast majority of professionals, faculty and students alike believe design is a special, intuitive act which cannot be initiated on logic-based computers. The roots of this problem lie in the "Is architecture an art versus science debate". The act of creativity thus remains firmly embedded in traditional means.

With thirty years of perspective since the development of digital means, the following inquiry regarding computers seems justified: What was promised? What was delivered? Was it successful? Although these questions really can't be answered until schools of architecture are full players too, they do set the stage for academia's involvement.

Assumptions:

Those who have the most interest in the topic and conclusion of this thesis are students, faculty and administrators of architectural schools. Descriptions of the way things are in practice and education are generalized and at times will taunt and chafe. The reader will even detect a strong bias. Elsewhere within, there is a discussion about action as a motivation for writing on this topic. It is the author's hope that by questioning, whether with anger or agreement, the reader's many responses will initiate dialogue.

This shifting to an Information Age attitude certainly is not the only problem area the profession is facing today. Architects and educators have continually tied themselves to one belief structure or another which usually ends up causing

them problems.

This thesis will focus on architecture schools whose goal it is to prepare students to be architects! It will be assumed that any curriculum modifications will be administered in institutions offering five year professional bachelors degrees in architecture (a first professional degree). This is still the most economical means time wise to enter the profession. Although others exist, they are all masters degree programs.

Significance of the Thesis:

Conditions are now ripe for transforming architecture curricula due to the availability of computers offering increased power and speed for decreased prices. Following the lead of institutions such as the Mississippi State School of Architecture,[1] many schools, plagued with budget shortfalls, are implementing purchase programs to put computers into the hands of students.

Representing the profession and academia (as both faculty and now as a student), the author brings a unique perspective to this topic. The manner in which the background was presented and the problem was stated has exposed biases, however, having viewed the issue from multiple perspectives is an advantage. The questions alone contemplated by this topic will promote dialogue within the associated institutions. The schools, departments, or colleges that pioneer computer

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[1]B.J.Novitski, "Computers Go to School," Architecture, (Spetember 1993), 147

empowerment will serve to act as test cases for the institutions in which they reside and schools of architecture contemplating similar actions.

Goal of the Thesis:

The goal of this thesis is: *To introduce digital means and information technology into the architecture school curricula in a way which acknowledges the present, respects the past and anticipates the future.*

Implicit in this goal is careful attention to attitude. Prevailing attitudes concerning use of computers have been formulated from outside academia. As architecture schools seriously begin this new pedagogical challenge, attitudes nurtured there will be spread by their graduates.

In dissecting this goal, the attitude becomes clear. The reference to the present suggests tolerance. The "players" must accept the fact that they are in the midst of a paradigm shift and nobody really understands its full impact. It also acknowledges that curricula already exist and converting them will be a delicate matter.

The reference to the past acknowledges respect for the traditional means and those individuals who choose to continue using them. Traditional means remain elegant and direct ways to communicate. This aspect of the goal also advocates freedom. With so much emphasis being placed on computers, situations in practice or academia often begin to dictate the means which should be used by professional, student, or faculty. This severely limits autonomy and has grave conse-

quences for architecture.

The future reference pleads for flexibility in a document (the curriculum) which is by nature rigid. Maintaining a conceptual rather than concrete attitude will create order within the chaotic climate of rapidly changing technological developments. The future also represents doing new things with existing digital means beyond the conventional uses in practice and academia.

Objectives of the Thesis:

Objectives in research will also be tempered by attitude. A transition of this degree will be difficult for all the players. As a means to the goal of computer integration, techniques to be used must be sensitive to all players.

Opening a dialogue which assumes that this transition period is significant enough to require training for faculty and professionals will ease these old dogs into learning new tricks. Students are accustomed to being in a position of having to new learn things, but professionals and faculty are not.

In determining utilization of digital means for players in the discipline of architecture, the following distinctions arise:

1) Architects will use computers to aid them in practice

2) Students will use computers to aid them in learning

3) Faculty will use computers to aid them in instruction

Computers and software combinations are resilient enough to adapt to the aforementioned differences. The players will

begin to understand that they as individuals are permitted to use the computer for uses which are significant to them. This point of view liberates the individual from defaulting to an attitude where only 2-D CAD and 3-D Modeling are considered significant for architecture and spawns creativity which can only spring from innovation.

Digital means entered the practice by offering an editable alternative to traditional means. Architects had little to do with the deployment of digital means and everything to do with the development of traditional means. This lack of "ownership" of the new and threat of abandoning the old have contributed to present indecision which has been one of the reasons academia has lagged behind the practice acquiring digital means. Special effort made to foster fusion between digital and traditional means would promote freedom of choice and reduce the alienation.

Since digital means have infiltrated our entire society, any parallels drawn between architecture and other disciplines will speed the learning curve and build confidence.

Methodology:

A multi-method approach to research was used for this thesis including: a literature search, the citing of surveys, consulting with resource people, obtaining input from committee members, and through a "belated ethnography" of personal recollections.

The result of research will be a narrative manifesto which steeps the goal transforming the curriculum with background,

presents the means to promote its implementation and proposed a vision which will sustain it in its future.

Included are a bibliography, a list of consulted references, a model curriculum proposing policies used in modification, an outline for a foundation courses for design communication which aligns traditional means with digital means, and policies which address the transition period, faculty development for digital means, and "schematics" for a virtual department located on the Internet complementing the physical one located on the campus.

Literature Search:

Several criteria have been utilized in a literature search to place digital design in a historical and social context. The following individuals have written over an extended period of time: William J Mitchell, Douglas MacLeod, and Nicholas Negroponte and tracking their opinions through time is well worth noting.

Periodicals and journals from practice and education have also been tracked to detect changes in emphasis or attitude on the topic of computers in architecture. Perspectives were broadened by drawing from tangential categories with topics ranging from the roots of debate between art and science in architecture, information technology, artificial intelligence, cyberspace, to observing how other sectors and society as a whole have dealt with the Information Age.

Surveys:

The results of informal student and faculty surveys conducted at North Dakota State University, Department of Archi-

tecture and Landscape Architecture before and after the adoption of the empowerment initiative there.

Contacts:

In preparation for developmental leave, the author of this thesis prepared a document which targeted resource people. This list contains people chosen to shed light on the topic area. Over the course of the year, the author has discussed the issues of this thesis with these people and others.

Graduate Coursework:

Graduate studies in the College of Architecture have relevancy to research and ultimately the thesis topic. Research Methods in the College of Architecture provided tools to find, organize and express within a framework of academic rigor. Design Communication Theory Seminar also in the College of Architecture, reviewed the writings of communication theorists and introduced critical analysis of information.

Outside of this College, in Management Information Systems a course entitled "Social Issues in Computing" reviewed the effects computers have had on society and the means society has used to deal with them.

"Belated Ethnography":

Personal experience and interest in the phenomena first sparked the idea for this thesis. Those many roles played have contributed insight. Personal observations will function as a belated form of ethnography. The experience of watching three generations of computers unboxed in a single firm alone within half a decade, prompted contempt for the first generation, tolerance for the second generation and promotion of

the third. Involvement with the first CAD equipped computer at NDSU, with an interface so obtuse it made hardworking architecture students proud of truly insignificant accomplishments. Being a sole proprietor of a single person architectural practice could not have been possible with out the aid of technology. As it is impossible to divorce this interest from the activity at hand, be prepared, it will be included.

The combination of first hand observation of computers in practice and education, sampling of opinions of those listed in this document and countless others too numerous to list, and (society-based) search through literature has prepared the author to confidently draw those conclusions which follow.

Definitions:

Following are words which may be unfamiliar or used in a way the reader is unaccustomed to. Several of the definitions were found in the glossary of Digital Design Media by William J. Mitchell, and Malcolm McCullough.

Algorithm :

Software program which works unattended to carry out tasks delegated to it.

Analog[2]:

Continuous representation having some formal similarity.

Application Program[2]:

Program which accumulates and operates on data to accom-

plish some useful purpose.

Bandwidth[2]:

Range of frequencies available as a communication channel. Corresponds approximately to data rate.

Digital Means: The use of computers for accomplishing tasks.

Empowerment: In the context of this thesis, the word empowerment implies the enabling students access to computers.

Gopher[2]:

Go-for. Menu-based browsing and retrieval software for obtaining files from a web of hierarchically cataloged servers on the Internet, without concern for physical location.

Internet: A world wide network of linked computers which have the ability to communicate with one another.

Means:

Out of respect to the author's graduate committee chairman, Professor Kirby Lockard. Professor Lockard special use of this word is essential since using it never lets one lose sight of the fact that all the tasks architects have is to a common goal, the building. In these times when "paper architecture" is so much in vogue, means provides a great reality check.

Mosaic[2] :

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[2] William J.Mitchell, Malcolm McCullough, Digital Design Media: A handbook for Architects & Design Professionals, 2nd Ed, (New York, Van Nostrand Reinhold, 1995) 467-484

Browsing software for the Internet. Provides graphical user interface to routine operations such as Telnet and gopher. Provides cross-references to other locations.

Network: The Linking computers together for communication, sharing software, documents and output devices.

Traditional Means: The using everything but computers for accomplishing tasks.

Virtual Reality: Presently in various stages of develop ment stages, it is the combination computers, databases and devices which give humans an illusion of reality.

CHAPTER TWO

Chapter Two provides background on digital computers and the related topics of information technology and artificial intelligence. Finally, it will investigate architecture, the design process, and the conditions of practice before and after digital computers from an information technology perspective.

The Information Age:

The technological development of the digital computer has had an enormous impact on society. Computers seem to evoke qualities of universality which fit into every situation. Like "Trojan Horses" of technology, computers are wheeled into diverse contexts. Those who were under digital siege, first turned to the computer as a new way to perform old tasks and in the process, discovered new tasks which only a computer was able to perform. In time, tasks are heaped upon computers until nothing can be accomplished without them. Computers first liberate and, in the end, dominate.

The twentieth century entered under the influence of the fumes of an Industrial Age and it seems it will leave amidst the hype of the Information Age. One can only be reminded of the plight of the gritty cities of the eastern seaboard and the stillness of once incorrigible steel mills to be convinced that indeed the Industrial Age has passed on.

What then of this Information Age which remains? A society whose economy thrives on information in lieu of manufacturing

what have become known as "durable goods" is indeed a puzzlement. How can anyone make a living on information? Who will pay for information? Do we pay fare for transportation or for knowing that seat is empty, what gate to go to and what time to go? Doesn't the airplane still depart, full or not, with or without us? Isn't the ticket we pass at the time of boarding just more information? It will take a long time before the full ramifications of this age are realized and then only after it too has passed, in retrospect, will it be fully understood.

The world's corporate sector has witnessed many changes in its move toward replacing material with information. To really understand this shift, back-up to a time before money existed, then you had to feed your wealth, build fences to contain it and clean up after it. The use of record keeping and tokens to symbolize material goods first appeared in Mesopotamia and initiated the ability to store information outside of the human brain.[3] Cash as a singular mode of payment has acquiesced to the check, then to an impression on a credit card, then to the magnetic impulse or series of audible tones. Consider money and the flexibility which computers have allowed transfer of funds, direct deposit and countless other financial world tasks with buzz word names. Monetarily, the world has been dealing with information age attitudes for quite some time. What is noteworthy here is the tolerance of society in general and financial institutions in particular

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[3] Arno Penzias, Ideas and Information, (New York, W.W.Norton & Company, 1989),42

to accept these multiple changes. Over the same period of time, architects have made few such changes and even at the threshold of the Information Age, they still tote around rolls of drawings under their arms. The real issue here for architects is not the medium but maintaining control over it.

Digital Computers and Information:

It is clear that computers have fostered the Information Age's expansion and perhaps they are entirely responsible for it. Ironically, the computer was a product of the Industrial Age. Our modern day computer sprung from seemingly unrelated developments and can be traced to the need to control rotation of game roasting over a spit, early clock movements, mechanical adding machines, "punch card programming" of weaving machines, the telegraph, telephone exchange relays, binary notation of numbers and letters to name a few.[4]

Modern computers are digital in nature, operating on the basis of the switches within them being open or closed, off or on. There have been many devices which have been responsible for this switching over the years, a final change from electromechanical vacuum tubes to lithographic printing on semiconductors has accounted for the most recent phases of downsizing allowing one to hold the computing power formerly housed in climate controlled rooms to fit on one's palm.

This binary property requires any data to be used by computers to be converted into this root two base. It is not

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2 Arno Penzias, Ideas and Information, (New York, W.W.Norton & Company, 1989), 90-97

surprising therefore that computers have an excellent relationship with numbers or anything which can be expressed numerically. Digitizing information, changing it, in a sense, from, as Nicholas Negroponte puts it, "from atoms to bits",[5] allows it to be transported through wire or fiber-optic cable, and bounced effortlessly off orbiting communications satellites. The Internet, a public accessible network linking thousands of computers world wide and its limited access counterparts operated by corporations and institutions have facilitated information transfer at unthinkable rates and connectivity. Suddenly the world is smaller because of enhanced access and transfer of information.

The computer's apparent knowledge results from the digital response, on or off. Any prearranged arguments resident in the software were put there by humans. At this point, computers are not advanced to where they can take charge as Hal did in 2001: A Space Odyssey. Digital computers may never become this advanced. In fact, the pursuit of artificial intelligence as it would be manifest in computers has initiated new research of human brains like no time in the past. The digital computer works in a step by step fashion controlled by a central processor following the pre-prepared instructions of programming. The brain has a "galaxy" of processing units performing many functions concurrently and seems to be controlled by memory. Since the brain and the computer work in different ways, they excel at different things. The

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[5]Nicholas Negroponte, "Bits and Atoms," Wired, (January 1995), 176

brain's power of recognition, making agile movements and linguistic comprehension are unsurpassed. Computers on the other hand is unsurpassed in their ability to manipulate numbers. [6]

Architecture, the Design Process and Traditional Means:

To say that architecture is the world's second oldest profession is perhaps an oversimplification and not in good taste but nevertheless, architecture has been around for a good long time. History has given Imhotep the distinction of being the first recorded architect living in Egypt from 2635 to 2595 B.C.. Imhotep was considered a god by his contemporaries. The role of the architect was by no means consistent from age to age or to place to place. The Greek word architect is derived from "chief" and "builder" and literally the architect was the builder which suggested an on-site presence. This may have started to change as teams of architects, each with different job descriptions, over-saw the expansion period of the Roman Empire, marking a time when architects were gradually separated from direct involvement with construction.[7]

Finally, architecture ceased being a "hands on" process

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6 Jeremy Campbell, The Improbable Machine: What the upheavals in artificial intelligence research reveal about how the mind really works, (New York, Simon and Schuster 1989), 11-13

7 Leland M. Roth, Understanding Architecture: Its elements,history, and meaning, (New York, Harper Collins, 1993), 105-108

and instead became a service symbolically determining an end product to be built for others by others. The more removed architects became from the site, the more it became necessary for them to rely on alternate forms of communication. Architects became intermediaries providing service to clients and documents to contractors. This separation from the site and the pragmatic issues which seem to dominate construction allowed architects to conceptualize, reflect on the "what-if's" and claim that the end product was architecture and not just a building.

Design services as provided by architects universally includes clients and users, addresses needs, sits within a context, requires unique solutions, and evolves a form. Termed the design process, it is the main component of architectural education and applied in practice as primary method of conceiving architecture. A design process or concepts like it have broad problem solving applications beyond architecture.

Examining the design process will uncover close links to information. Information is gathered, manipulated and communicated. Initially information is approached in an open and questioning manner and finally information is disseminated in a closed knowing manner. The process cycles in varying frequencies; sometimes within the mind of a single person, a team with and without the client, or even involving a whole nation. Seeking, solving, and showing are familiar words that closely characterize these three recurring phases.

As we contemplate future change, it is often helpful to

consider the past which was the future of those who proceeded us. On what occasion did a prehistoric architect first scratch a mark in the sand symbolizing a space defining element? Did controversy arise as observers were compelled to imagine this early form of virtual reality? How liberating this must have been for the individuals whose only recourse had been to actually place materials to experience the space symbolically.

Traditional means evolved out of a need for effective design communication and date back to the roots of design itself. The drawing commonly associated with practice as a conceptualization, communication ,and documentation device has roots running parallel to our earliest knowledge of the profession. Sketching or scratching in limestone and multi-colored inking on papyrus were uncovered from ancient Egypt. Floor plans indicating wall thickness and location of openings have been inscribed on clay tablets discovered in Mesopotamia. Legal descriptions in the form of written documentation and specifications were utilized by early Greek architects who worked closely but "drawing-less" with stone masons. In early Rome the emphasis shifted back to drawings as witnessed by Vitruvius's complete listing of desirable attributes of architects in De architectura.[8]

The drawing has historically provided architects an opportunity to preview or exhibit work. This ability to consider a

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[8]Leland M. Roth, Understanding Architecture: Its elements,history, and meaning, (New York, Harper Collins, 1993), 107

future, sans construction, is a great speculative tool. In addition to design-related uses, drawings have long been cherished for their beauty and the insights which can be gained about their creator. As architecture is the physical embodiment of conceptual thought, the drawing is the means utilized to externalize these thoughts prior to their realization. These many levels of meaning associated with drawings make it difficult for architects to consider alternate means of communication.

Although the infusion of technology through the ages has constantly affected the end products of the architect's labor, it had little effect on the process. The media of drawing changed over the years from stone to mylar followed by a constant parade of implements from chisels to technical pens. Through it all, one thing remained constant; the implement had always been hand held and the marks were always placed directly on the media.

Architecture & Digital Means:

In the last decade, technology finally began to have its effect on the design process too. Keyboard, monitor, and "mouse" replaced the latest family of mark placing implements. Mark placing information was entered by the designer's hand as it manipulated a "mouse" and an alpha-numerical keyboard. Placing marks on media became a delayed event performed by still another device after marks were previewed on the monitor. Initially, architects first stood and watched this event in amazement. Later they just went out for lunch

and let it happen.

The focus here on the drawing has been intentional since, for ages, it has been the skill which set designers apart and allowed the "idea" of design as art to flourish within a profession which had long since shifted toward the science. This ability to express one's self graphically has always been a sign that one had "what it took" to be an architect. With a complete shift toward computers, it seems these drawing skills could be replaced by the hand/eye coordination and prowess on video games.

Stephen Jay Gould penned an essay on the panda's clumsy adaption of a wrist bone to function as a false thumb accommodating their new diet of bamboo. Gould suggests that the "qwerty" keyboard is the "panda's thumb of technology". This keyboard was chosen because it was slow, inefficient, but didn't allow the mechanism to become jammed. Although, studies have shown tremendous increases in efficiency could be gained by rearranging keyboards, no wide spread move has been launched to do this.

Gould's moral here is an example of how nontechnical social context determines the outcome of a technical issue.[9] This lesson has strong parallels for architects. When digital means finally crept into architect's offices, as the bastard son of engineering it didn't resemble anyone in the room. Indeed, it was these engineering consultants of architects

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[9] Chuck Huff, Thomas Finholt, Social Issues in Computing: Putting computing in its place, (New York McGraw-Hill 1994), 1-3

who made moves toward digital standardization. Consultants like "closer pitchers" in baseball step in at the final innings of an architecture project while construction documents are being produced. This is a closed/ precise task consisting of curves,vectors and numbers. A hardware/ software combination which became overwhelmingly standard had no provisions for the open, imprecise needs encountered in the conceptual design phase.

Uniformity of digital means among architects was in the best interest of consulting engineers. After all, their client base was limited to architects. Architects prior to the big burst of digital deployment, after resisting for a variety of reasons, were desperate for advice. The American Institute of Architects even made a pitch for a software package but even their product(DataCad© by Microtecture) even lost . Pressure from large corporate clients as well as the federal government in the form of requirements for digital documents and favorable rate structures from consulting engineers pushed the profession over the digital edge.

Computers were introduced into the architects's work place to perform a task which was already being accomplished without them. The computer's ability to aid the designer with reusable and editable drawings was the prime reason computers found a home at drafting stations. The deployment of computers in architect's offices was limited to the most pragmatic of uses and remains virtually unchanged today. Most architects have yet to discover those tasks only made possible by computers.

It was a foregone conclusion to researchers pioneering the investigation of the computer's potential as an aid to designers that the computer could be used as a replacement for drafting. Mathematics already allowed numerical representation of curves and vectors and therefore a natural application for the computer. What wasn't anticipated were the problems caused by a poor interface.

Computer programmers initially had little concern with interface. After all, they already knew the computer inside and out, the real job for them was assembling algorithms (a series of instructions or steps required to allow computers to perform software tasks). Computer users however had a different point of view, and this has resulted in the creation of entire computer platforms and operating systems to fulfill the need of user friendliness.

Interface issues continue to be a problem for architects especially in this period of transition. Architects who prefer blue enameled pencils to yellow ones and yellow tracing paper sold in Cambridge MA to the stuff available locally found it hard to warm up to alpha numerical commands and mouse driven menus coming between their ideas and the media. The industry standard hardware and software combination is completely devoid of tactile attributes providing no feedback of the kind which was characteristic in traditional means. Is this overt nostalgia or a perfectly reasonable request which those who were outfitting computers as digital means to have these issues considered?

To be a "real" aid, it was reasoned by researchers three

decades ago, computers needed to assume a role in decision making on a conceptual level too. Nicholas Negroponte pioneered computer research of design applications at MIT's Media Lab. The following quote sums up the expectations researchers had for computers.

" Most computer-aided design studies are irrelevant in as much as they only present fashionable and faster (though rarely cheaper) ways of doing what designers already do. And since what designers already do does not seem to work, we will get in-bread modus operandi that could make bad architecture more prolific"[10]

Negroponte's prophetic realization that digital means might not produce better design must have been a crushing blow.

It is no accident that three decades ago, Design Methodology, then the "hot" topic in architectural education was being explored in a parallel way to research in design computation. Christopher Alexander published his doctoral work from Harvard in 1964.[11] It argued that new methods were needed to deal with design problem solving. Increased complexity of design problems, new materials constantly being developed, and changing social and cultural patterns placed design-related information in a constant state of flux.

Alexander's background in mathematics led him to naturally utilize the concept of sets, subsets, variables, and binary

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[10]Nicholas Negroponte, "*Toward a Theory of Architecture Machines,*" Journal of Architectural Education, (March 1969)

[11]Christopher Alexander, Notes on the Synthesis of Form, (Cambridge: Harvard University Press, 1964), 3

notation to impose order on this rapidly growing undulating body of information.[12] A methodology based on mathematics allows digitization and computer manipulation. On the surface, it seemed that Alexander had found the link which would enable computers to assist architects in the manner that Negroponte had anticipated, however, it never really caught on in the profession.

Architects assume the role of generalists and therefore don't trifle with technology. They enlist the aid of consultants for everything requiring calculation or the least bit of specialization, preferring to function as generalists. This posturing is not cheap, since fees must be shared with these same consultants. Architects are much more interested in the building anesthetically, this has become "their" area of specialization. Architects also sit in a position of control, between the idea and its realization, the clients and their needs. They solicit contractors, and oversee construction. These are things which consultants rarely do. Perhaps it is this break between art and science, manifest in the use of consultants which leads architects to reject technology's infiltrating their offices too. This break seems hard to understand. An outside observer Joseph Bronowski, states the following in his book, The Visionary Eye:

"In the intellectual revolutions of the past, architecture has been a point of fusion: the most sensitive point at which new ideas in science and new conception of the arts have

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[12]Christopher Alexander, "The Theory and Inventory of Form," Architectural Record, (April 1965), 177

crossed and influenced one another. Men have learned both, unconsciously, from the daily sight of great buildings. Today, the architect bears the same responsibility for making science as well as art visible and familiar, and for having each influence and enter into the other. Architecture remains the crossroads of new science and new art. If the architect is willing to make them one, by learning to live naturally in both, there will at last be fine modern buildings, and citizens wise enough to see that they survive."[13]

In his book championing the remarriage of science and art in architecture, Garry Stevens laments that, " In no other discipline is the tension between the two cultures more evident that in architecture."[14]. Robin Baker sheds light on those cultures by citing C,P. Snow's lecture of 1959 in his book on design and computers. Snow describes the gulf between two cultures, art and science, whose practitioners had little understanding of the influences that had linked science and art together in earlier times. During the eighteenth century, it was impossible to separate artistic content from technological structure; they were a harmonious and integrated whole. Snow reasons the industrial revolution was responsible for removing art from everyday culture. Baker suggests that it is the computer which will rebuild the bridge between

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[13]Jacob Bronowski, The Visionary Eye: Essays in the Arts, Literature, and Science, (Cambridge, The MIT Press, 1978), 56

[14]Garry Stevens, The Reasoning Architect: Mathematics and Science in Design, (New York, McGraw Hill, 1990), 15

art and science[15] and attempts to prove this by showing the computer used in an artful way.

The two decade lag between (R&D) efforts and the general acceptance of computers in practice can be attributed to a number of issues. Certainly, economics was a major factor. Time has proven that the longer one waits the more one gets for less when it comes to buying technology. The other aspect perhaps is tied up in a moral belief structure which has attached itself to the profession.

The suggestion that a "machine" could make decisions in assisting architects has never been taken seriously. If/Then logic seems to be a threat to the intuitive magic which the act of creativity is cloaked in. Like a creed or mantra, architects recite a list of universal beliefs related to digital means and as one passes by during one of these rants, the most pronounced message is that computers are not design (conceptual design) tools. This comes from a profession whose vast majority of principals don't personally use digital means.

The fact of the matter is that standard hardware and software combination has such a steep learning curve and an interface so foreign to the profession that principals and project architects claim that they have not had the time to learn (CADD). Consequently they administrate a situation which they have little control over. As in so many areas in

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[15]Robin Baker, Designing the Future: The Computer in Architecture and Design, (New York, Thymes and Hudson, 1993), 12

the past, architects have found another reason to enlist the aid of technicians (experts) to hold their hands. This attitude cultivated by principals and project architects toward personal use of digital means keeps them from using the computer for those tasks common to most other office settings.

Presently, it is the architects' employees who use digital means for doing tasks primarily limited to production of construction documents and more typical "office tasks". Many traditional means have been "dropped" and there has been little or no attempt to fuse digital with traditional means. This is evident by the presence or absence of certain items of computer hardware. Networks are used as a means to access construction document storage and not for communication which is very common in the non-design office world.

Architects universally believe in the limitations which they have unwittingly placed on computers. They do this to the point where they will hire yet more consultants to do specialized computer aided tasks which, with the addition of peripherals and software packages to computers they already own, they could easily achieve themselves.

Practice has used digital computers only to replace those tools which forced perfection out of their otherwise "freehand". This freehand is still theirs. Any expansion of the role of digital computers in design would deny architects a part of their body: their freehand!

For the most part, architects called it right. Brains do deal better with "open" information. This happens to be why the brain directly operating the hand and pencil is still

utilized for conceptual design. On the other hand, computers deal better with "closed" information. This provides understanding into why architects have limited use of computers to the closed function of construction documents.

What is absent in the present is a fusion between traditional and digital means. In emphasizing fusion between old and new techniques, a situation will develop where the alienation and anxiety which runs rampant within architecture schools and practice will subside. The resulting climate will spawn creativity and innovation in the way computers are integrated.

Architectural Education and Digital Means:

Computers have not been entirely absent in architectural education. In the past,the cost and availability of computers worked to deny access to those who could benefit the most from exposure to them. Computer facilities, commonly the pride of the institutions who could find it within their financial grasp, were usually used only by faculty and students with strong motivation. Many "state of the art" facilities are so "special", in fact, that graduates would be able to find "real world" parallels only in the most prestigious architectural firms

Usually a limited number of computers were kept "under glass" in a special place with use closely scrutinized. It took incredible tenacity on the part of students to just get work time scheduled which also posed administrative nightmares. Architecture education, from the student's point of

view, has never been a nine to five proposition, but security concerns and the hassle of computer timesharing has discouraged all but the most digitally enthusiastic students.

Schools were in error when they felt that they actually needed computers to learn about them in those times when they were out of reach for a variety of reasons. "Computer-less" computer courses would have rectified many of the problems which have arisen as a result of no course work at all. With an education strategy such as this, computer education could have begun shortly after the research had been released and the professional decision making would have been eased due to a raised level of awareness. Similarly, today virtual reality, though virtually inaccessible in anywhere near it's final form, has the potential to be thoughtfully discussed in a classroom or seminar setting.

Summary:

This introduction follows many threads tied to the present state of digital means in the profession of architecture. It generalizes on a situation which has many specific explanations for being the way it is. No one appraisal of such a broad area of concern can hope to accurately depict the global condition which architecture education and practice find themselves in during this transition period. Future generations will wonder what all the fuss was about but optimism would suggest that everyone involved will have solved all the problems by then.

The deployment of digital means marks one of the most sig-

nificant happenings architecture has ever experienced. As service providers, architects gather, manipulate, and communicate information (seek/solve/show). With digital means, architects can embrace all that the Information Age has to offer. But instead, architects who successfully avoided the Industrial Age sit in relative ignorance.[16] The transition into an information age has much more to do with challenging beliefs and developing attitudes than anything else. The same sort of rigid belief structure so successful in galvanizing architects during modernism has kept them from advancing into information areas too.

Architects have, for example, intentionally shunned involvement in the commonplace sectors of the built environment. Low budgets, low notoriety, and multiple copies were enough to repel most of them. Digital means combined with Information Age tactics would allow professionals who acknowledged this sector to actually do a good job in it.

Architectural schools were the universal source responsible for disseminating those beliefs which architects hold so dear. The three decade wait-and-see attitude which education has had toward digital means and the Information Age issues has perhaps been at the root of the profession's problem too. The next chapter will explore the problems and sub-problems with a focus on action.

16Douglas MacLeod, "Architecture in the Computer Age," The Canadian Architect, (February 1987), 41

CHAPTER THREE

Determining Precepts:

The precepts in this chapter respond to the problems previously stated and will be central in the proposed solutions to come. Since architecture schools have seldom taken a comprehensive look at reshaping to develop an Information Age attitude and incorporate digital means, the messages sent are to date often confusing.

There are many explanations for this confusion, the empowerment initiative fosters grand illusions of digital utopias and suddenly past mechanisms and means are postured out of existence. There are always individuals present within any institution who continually voice personal agendas in harmony with their own interests. Polarization also develops related to group ambitions, interests, forcing "either-or dichotomies" which wouldn't have happened on their own. There is no denying that among all the "players" there are those who are especially enamored with the means not the ends. Traditional and digital means have become the ends for many, crowning them with expert status.

Administrating amidst these "distractions" can more often than not be a challenge, it is seldom possible to grant the wishes of a single individual or group without in some way impacting the others present. Any loss of individual freedom or autonomy for example which relates to the means in which something is accomplished within an academic or professional setting would have been a remarkable thing prior to the

deployment of digital means. It is the hope of this author that in times to come it will revert to its previous status.

The goals of empowerment and fusion favored by this thesis offer a logical path for reshaping pedagogy. Seeking to remove digital means from the purview of experts and the high security environment of the past and spread them around studios to become as common as old study models is a victory by itself. Empowerment and ownership of traditional and digital means stress universal involvement at which base levels of understanding are expected and mastery becomes the prerogative of the individual. Traditional means will continue to flourish, digital awareness will start to grow, and fusion between the two will develop into an exciting new alternative.

Central to reshaping pedagogy in architecture schools is acknowledging how groups and individuals will be effected by this major paradigm shift. Administrators, faculty, students, principals, interns and staff from academia and practice makeup groups whose individual rights have already been jeopardized by the deployment of digital means. All have felt alienation due to ignorance of digital means based on fear. Past issues of injustice in the areas of academic freedom, student relations, and professional autonomy rise to the top.

Students, aware of the rigid requirements for employment relating to digital means, have inadvertently adopted the highly pragmatic view of computers initiated by practice. Their lack of understanding of the difference of what is being done digitally versus what could be done leaves them

grumbling and questioning their university education and favoring a narrow technical school approach.

Graduates have been denied employment because they lacked knowledge of a name brand software package in spite of an intern program which assumes that students will further their education "on-the-job".

Faculty have been called on the carpet for suggesting that students use one means or the other when the student was inclined to the contrary. "Digital correctness" has arrived in design studio denying a professor's academic freedom. There will be faculty members who will never feel comfortable with digital means who still have a great deal of knowledge to impart.

Architects missing the opportunity of experiencing digital means while in academia are considering career changes rather than submitting to the rigors of learning the industry standard software/hardware platform. Ironically, the traditional means they did learn in schools and have used to date still serve them well.

Although disturbing to some, the analogy of human beings referred to as computers or vice versa opens some intriguing comparisons. The simple elegance of a hand holding a soft lead pencil eliminating keyboard, mouse, CPU, monitor, ram, megahertz, storage media, printer on its path to making marks on paper can not be denied. Traditional means were not obsolete when digital means were deployed. It can be argued that digital means are more efficient (possible) but they will never be as direct.

If the computer can be viewed as a willing servant, one is allowed to accept or reject digital means based on such frivolous basis as enjoyment of the traditional means which computers seek to replace. It is fundamental for faculty, students and professionals to work in the medium of their choice. Design and the manner in which it is accomplished will continue to be a very personal process. Fusion between traditional means and digital means open many opportunities and crossovers.

Faculty should be assured that they need not wholeheartedly embrace computers but must accept the fact that students will. Since faculty will utilize computers as a teaching tool, students as a learning tool and practice for the production of architecture.

What must be stressed throughout the deliberations empowering students and faculty with digital means to design is that this is indeed a transition period for both camps. Faculty attitude and training would be a central empowerment issue and certainly needs addressing. Students have considerable exposure to computers upon entering the university setting. These "global" skills must be redirected toward architecturally related tasks.

Some Caveats:

Gender and economic issues have always been present in architecture schools and empowerment will likely involve review in light of reshaping. Special professional program fees and mandates for computer empowerment may put the pro-

fession in the hands of only those who can afford the extras. Extras have always been associated with traditional means but certainly not to the extent which they are with digital means

Digital empowerment is expensive. Administration, faculty and students will each bear very real costs for this mandate. As empowerment raises the level of excitement within an institution and suggests progressive thinking, forward vision and similar glowing expletives, but it's easy to lose sight of the fact that students may reject the program for economic reasons. It would be prudent for institutions to have a program in place to distribute aid in cases of need. It is one thing for a faculty member to reject digital means because of a personal belief but if a student has been denied exposure due to the economic status, that is a different issue altogether. On a positive note, the mandate of computer purchase makes it a legitimate university expense eligible for student financial aid.

It is undeniable that in the past, architecture was a male dominated profession. This situation has changed dramatically in academia and although parity has not yet been reached great improvement has been shown. This may not be the case in the computer world of the Internet where there has been much evidence of gender bias against females in news groups. Empowerment means frequent exposure to this environment and students must be advised of the situation.

Both male and female students entering university today have had equal opportunities to use traditional and digital means in high school. Industrial arts classes which provide

initial drafting and mechanical drawing exposure to students now require participation of both sexes. The administration must anticipate the possibility of inequities based on socio-oeconomic issues which relates to available resources in schools from which students came. This was hardly an issue with traditional means adequately "driven" by use of a wood pencil.

Schools of architecture can learn much from what has previously transpired in other disciplines. Social and ethical issues have long been associated with the introduction of digital means. Placing computers in business, industry and government have brought both positive and negative results as well as expected and unexpected outcomes. It is recommended that those who are involved with implementation of programs introducing digital means investigate the experiences of others.

Using computers brings a new set of work related health problems. Inputting data, watching it displayed requires long hours of extreme concentration in sedentary positions. Drafting brought its own sets of health problems especially related to eyes and back. The computer has required placing the work of the world on the wrist, neck and eyes. There is a role for design of a more anthropomorphic work station but until that time comes, computer users should be aware of the problems and deliberately act to curb the ill effects. Just the manner which students tote computers from place to place can may cause spinal problems.

Due to the cost related to digital means, concerns of

security are elevated. Casual neglect by faculty and students are sure to incur losses beyond what had become the norm. The institution needs to develop and inform faculty and students about the issues of security and together act to protect this expensive property. Perhaps always locking the computer in a secure place is a start. Carrying it in luggage which doesn't shout "I am a bag for carrying a computer" is another tact. Essentially, loss prevention here is a matter of good common sense and insurance.

Digital Means brings with it special ethical issues. Software piracy being at the top of the list along with the possibility to reuse digital files for one's own use (cheating). As creative professionals, architects, faculty and students who are studying architecture should understand the concept of intellectual copyright. Digitizing anything enhances our ability to copy, upload and download files with no loss of quality. Traditional analog methods have give the same advantage except for the issue of quality loss. Make one hundred different generations on a photocopier and compare the last one to the first one. Besides reviewing official policies already present on university campuses concerning digital copyright, security issues must be present protecting software and documents on personal computers and on network servers

CHAPTER FOUR

This chapter deals with the application of goals, objectives and precepts in the context of architecture schools. By narrative or scenario, problems previously formulated will be addressed in the context of the institutional setting.The preceding information sets the stage for the reshaping to follow.

A prerequisite to action on any ground is empowerment. Just the idea of computers reaching critical mass in an educational setting causes everyone involved to shudder. It is soothing to know that empowerment has happened before and is happening concurrently at other institutions. This thesis has opened channels of communication between architectural education at the University of Arizona and North Dakota State University which share information and coping strategies.

Curricula formalize the entire effort of an architecture school dealing with time and course content, and result in a document which guides students, faculty and administration alike. Paying attention the curriculum is the first step in reshaping pedagogy.

Two fundamental areas where ownership of digital means are crucial, faculty use of the computer as a tool for teaching and student use of the computer as a tool for learning. Everyone has labored too long under the conception that the way practice used computers was the "only" way.

It seems prudent that we start embracing the future with a rigor which was absent in our avoidance of digital means. The

future through digital means is now in its infancy but the impacts which are being discussed may shake the very roots of the profession. Regular course offerings which would address the future are a must if architecture is to remain involved with space and form.

Empowerment and Beyond:

This section investigates attitude since nobody knows what will happen after the boxes are opened and the cords are attached. It's hard not to make a big deal concerning this paradigm shift where students are being required to spend large sums even by today's standards to be able to have a computer at their side. Everyone from the university president down needed to be convinced that this is a worthy thing to do and it won't backfire in their collective faces.

There are two camps with two different attitudes about empowerment. Basically they line up on the side of control or freedom. Those who are inclined to never use digital means, are convinced that computers are "very" special and worth more attention than they can give. The other group claims that computers are just multi-faceted tools which students and faculty will settle in with quite naturally.

Reports are written, meetings are held and after much deliberation, there are concrete decisions made. Just as architects never make a move toward detailing a project until it is a certainty that it will at least be bid, the same goes for making personal plans responding to empowerment on the part of faculty and students.

After digital empowerment becomes a reality, students will gain continuous control and access to this consummate tool. They will prepare their assignments digitally, on their own terms, where and when they choose. Empowerment isn't forcing students to buy or lease computers as much as it is validat-

ing this action. Architecture schools already receive many calls from students or their parents making inquires about which computer and software purchases are recommended.

An institution which shows the commitment to write policy, invest in infrastructure and transform curriculum is sending a progressive message to students. Remember these students know exactly what they are walking into. It is the faculty who are unsure of their steps. A rearward glance may give this issue the perspective of history.

There is seldom a reference to the history of architectural education which doesn't compare the Beaux Arts to the Bahaus. What perhaps isn't so publicized is the process within the institution itself which allowed this to happen? Was there a vote on ideology? What happened in schools of architecture when professors curtailed exercises and design problems which espoused the glories of an eclectic, traditional approach in favor of the functional, rational simplicity of modernism? It is doubtful that all "beaux arts" professors took early retirement, someone must have had to return in the fall with a "thoroughly modern" attitude. What happened to all the French curves? One expects that a bit of both philosophies lingered for quite some time. Each tolerating the others because when it came down to individuals, respect preceded ideology anyway.

The shift from traditional means to digital means and informational technology is equally as traumatic since it goes beyond mere fashion of the day and strikes the desk-side manner of professors in the design studio. How will the pro-

fessor who "slings" a roll of tracing paper on student work as a means of commentary and assistance conduct a desk crit when the image in question is on a monitor? Will discussion be centered around the computer at the expense of the design exercise?

To answer this and other questions, one must reflect on the parallel situations using non-digital means. No, the discussion will not be about the computer. Remember everyone has one, no novelty here. Perhaps a layer of digital trace labeled with the date and time of the crit will be available for the professor to scribble on. Just as today's professors are not required to demonstrate mastery of the broad expanse of traditional means, tomorrow's counterparts will not be required to show parallel mastery of digital means.

Design studios will remain places where students learn through doing, and professors will continue to nurture, critique and control the tendencies of overuse which students have historically abused. The capacity for such abuse will be naturally amplified by digital means, one can almost predict the outcomes but overall, there will be positive and negative effects on form and it won't take professors long to determine those regardless of their stand on digital design.

Design studio will not be the only situation where faculty will encounter students bearing computers. Empowerment of students (and faculty) will impact the lecture hall or seminar room. Further on in this thesis, the section on learning and teaching will investigate digital augmentation of lecture and seminar courses.

With participants each capable of bringing their computers to the lecture hall, many possibilities arise. Here as before, traditional means were not entirely outmoded. Skills delivering a lecture, with style and grace still are possible without digital means. As with drawing, the act of teaching and learning using traditional methods of speaking, listening and taking good notes couldn't be anymore direct at linking the brain and the senses involved. How many times have you been to a verbal presentation when the speaker asked the audience if they could be heard without the microphone? Even this innocuous device destroys intimacy which is so important to speaker and listener.

Faculty may, with good reason, elect not to use digital means in lecture and certainly not for seminars. How can mere faculty compete with this marvel of the twentieth century sitting in front of students. This is a real problem and one which shouldn't taken lightly. Faculty should have to prerogative to conduct a lecture with or without the computer and the authority to advise students to turn their computers of at times. Students may have good reason not to use computers except when digital means are on "center stage" of in a course.

Reshaping Curriculum:

This section will first present several points of view concerning architecture education by groups and individuals who feel that change is in order. Following this is a very abbreviated tour of a typical curriculum. In conclusion, policies will be applied to the area of curriculum.

Curriculums offered within architectural education differ from institution to institution. This diversity and uniqueness account for uncertainty and surprise when graduates from different institutions team up in the real world settings to create architecture. Complete educational autonomy is denied however by both the National Architectural Accrediting Board(NAAB) and National Council of Architectural Registration Board (NCARB) through recommendation and control. These organizations at academic level control accreditation of architecture schools and at a practice level control the individual licensing of architects.

A doctoral dissertation of Michael Bunch published 1992,[17] set out in search of a core curriculum. He found in spite of a lack of apparent coordination between schools that indeed a core curriculum did exist. Mr. Bunch seemed to forget that leverage of those regulatory boards already have on architectural education.

This dissertation was the first volley of a notion espoused by the NAAB and NCARB for reciprocity between schools due to

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[17]Michael A. Bunch, "Core Curriculum in Architectural Education," (Ph.D. diss., University of Houston, 1992)

our highly mobile society. Yet today, students are seldom admitted with advanced standing into architecture programs. There must be a reason for this phenomena. Another issue covered and certain to raise debate concerns a perceived need for specialization in a field which is unique today for it's generalists. These examples are brought up because, if the NAAB and the NCARB feel they have a mandate to meddle in the affairs of individual institutions to the extent shown above, perceived inaction in resolving the dilemma of integrating digital means into existing curriculum will surely catch their attention.

Much criticism has been leveled against architectural curricula by the field of education. Mr. Bunch's dissertation questions studio as a prime vehicle for architecture education. The traditional studio stands out as an unorthodox approach as compared to the rest of education. On the other hand, many other branches of study are actively seeking something akin to architecture's design studio to add relevance to their curriculums.[18]

A curiosity which should be brought up at this time is the fact that architecture school faculty are typically not educated to educate and architects are typically not educated to manage businesses or personnel. Perhaps the architect's belief structure, which must have been programmed during their academic experience by promoting the myth that architects can do anything, has contributed to this dilemma. If

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[18]Michael A. Bunch, "Core Curriculum in Architectural Education," (Ph.D. diss., University of Houston, 1992), 171

one could listen in on the line of reasoning which fuels this idea it would sound like this, "The design process can be applied universally and if one can create buildings after all, surely education and or running a business can't be much different." This may not be far fetched and warrants attention if the profession is to survive.

Although the above topics are beyond the problem statement of this thesis, architecture schools need to critically evaluate their how their programs relate to education and the state of the practice today. If institutions don't act on their own, outsiders (NAAB & NCARB) who will make "reform" their business will do it for them. Maintaining autonomy, requires action on these fronts.

The studio is the major thread running through architectural education. It is an academically expensive proposition requiring great amounts of space, time and high faculty to student ratios. Yet mastery of design, the unrelenting search for a conceptual basis of form, continues to separate architects from builders.

Many scholastically proficient students lack the impetuous nature which sparks creativity and many who excel in design often lack rigor in their more typical course work. Practice offers positions for both of these camps. However, professionals need to straddle a fence between theory and reality, practicality and excess, between information and material. To excel, one must be able to fit into both groups.

Beyond design studio, curricula are made up of a collection of general and architecture courses which are either required

or electives. Most curricula have internal flexibility through electives allowing students to pursue individual areas of study. Often, students choose an appropriate "partner" for architecture which after graduation may turn into an area of specialization.

Students are usually encouraged to take general education courses within the first couple of years and architecture specific courses appear during each year. A glut of hopeful students line up as freshmen to join the ranks of the profession. This is curious because informal surveys show that most of these "would-be" architecture students have never met an architect and don't know what architects do beyond the obvious involvement with buildings. It is not uncommon to have four to five times as many students as there are permanent second year positions available.

First year lecture survey courses concentrate on elevating student awareness by exploring the built environment, the concept of design as problem solving, and allied professionals who deal with the environment at different levels than architects. This course is usually taught by a single professor who augments his lectures by parading the entire faculty in front of the class to present their special areas of interest and expertise.

Many schools fit a design communication class into this first year featuring coverage to the entire class or to a top ranking portion. These students have not been admitted into the program until the end of the first year and more often than not, there will be students who take the design communi-

cations course and leave the department. Offering an energy intensive, nurturing course such as drawing to the staggering first year numbers becomes at times unreasonable.

Second year for most students is the year they first feel they are a real part of the school. They usually for the first time have a permanent desk in conjunction with a beginning design studio. This becomes an intensive introduction to architecture with hands-on relevancy, criticism, and the introduction to studio culture which may be the allure which drew so many to architecture in the first place. Time-work coordination is usually not well adjusted for these students, (some individuals never succeed in this) and prior to the due date, they experience the infamous all-nighter, something that upper-class-persons are experts at.

Filling out the second year in addition to studio and general education courses is an architecture history sequence (some schools offer this course during the third year).

Subsequent years of design studio offer concentration in various areas by agreement and by virtue of faculty assigned. One level may be devoted to buildings, and another to urban context with buildings. Finally, a fifth year adds additional faculty conducting mini studios or relating in a one-to-one relationship with students.

Coursework offered by the department ranges from theoretical to practical in lecture and seminar form. Students take lecture courses in design methods, material and construction, and several series of courses devoted to those technical giants of structures and environmental controls. As in the

first year survey course, faculty continue their parade of interest and expertise this time to fourth and fifth year students in a seminar setting.

Amidst the electives and required courses offered within most programs, lie two introductory courses, one entitled something like "architectural graphics" the other called " Introduction to Computers". It is the recommendation of this thesis that these courses be discontinued in favor of a new information-based foundation course. This course could be offered split between first and second years or offered completely within the second year while students are taking the beginning design sequence. This thesis provides a more detailed explanation of this course in the next chapter.

This information-based foundation course will be (with some exceptions) the only skill-building course offered by the curriculum. Most of the general education and architecture courses including studio will benefit from this initial information overview.

As with previous graphics courses, basics were built upon as students were challenged to communicate design solutions. This does not prevent advanced offerings in any aspect in traditional or digital means. There will be students who want to specialize in a particular aspect of traditional or digital means. This, as always, will be encouraged but digitally, requires the institution have advanced facilities which are capable of supporting this.

The physical and social composition of studio provides a place where ideas and techniques are shared and discussed.

New traditional means for example are always being explored by students and this accounts for a continued skill building between the offering of the foundation course and graduation.

In general,students should be allowed freedom to use traditional or digital means except when one or the other means is being highlighted in a problem or exercise. By allowing autonomy in this area, students are encouraged to make decisions concerning the best took for the task. It follows here that faculty would be afforded the same freedom to exercise their judgment in using computers as a teaching tool.

The college catalog already establishes content for courses offered by a program. Faculty most likely have been given teaching assignments and have already taught these courses (some for a long time). Academic freedom allows these courses to be conducted as the professor sees fit but more than likely, the drive for empowerment has required specific commitments for digital content by faculty in these courses.

Faculty may determine there is no reason to use digital means for their courses and this might be true. Many courses will proceed as before with digital means and the network utilized only in "global" ways sometimes just to replace paper. Other courses will be supplemented by faculty's use of digital means to present content in class or faculty's offering students the use of interactive multi-media to review content out of class.

Technical courses have the most potential for change due to the availability of digital means. Possibilities for digital use come from redirected use of "global" software applica-

tions, the more typical utilization of 2-D and 3-D CADD software packages, and the introduction of simulation software with its ever narrowing focus. Student exposure may range from just knowing that a task can be done digitally to classroom demonstrations to mastery which can support design decisions. Many technical courses give awareness to future professional "generalists" who will, in the end, enlist the aid of consultants for these aspects of their service. This makes mastery of narrow simulation software questionable and may relate more to the indulgence of individual faculty than an actual need on the part of students.

As with non-technical courses, faculty lectures in the classroom and student learning outside the classroom setting may be augmented by presentation and interactive multi-media software applications.

Networking students with faculty and the world may prove to be the most significant learning experience available through digital means. If recent developments are any indication of what is to come, the Internet will be our primary information source. Seeking, solving and showing will all start and end here for the service oriented profession of architecture.

Learning and Teaching with Digital Means:

The computer is perhaps the most resilient thing man has ever conceived. Just listening-in on the lunch time chatter of strangers will prove this. People have a shared interest in a device which performs their divergent tasks. Every table represents a different view of computers, physicians, engineers, astronomers, auto mechanics, musicians, accountants, attorneys, it is a never ending list.

These differences follow us back from lunch and into architectural education too and continue on into individual offices of professors and onto desks of students. Not all faculty use computers in the same way, not all students use the computer in the same way, but there is a fundamental difference in the way each group uses computers.

No two faculty or students will utilize digital means in the same way. Each will develop techniques which will help them, teach and learn. This divergence will allows students to teach other students, students to teach faculty, and faculty to teach other faculty. There is sure to be a whole lot of learning going on.

Just speculating on the obvious traditional means utilized in the lecture and seminar courses one finds students in an effort to learn bring pens, pencils, notebooks, assignment date books, pocket calculators, and textbooks. Faculty in a teaching mode distribute syllabi, assignments, class notes, and tests all using paper as a medium. Faculty lecture presentations utilize chalk board, white boards, overhead pro-

jectors with transparencies, slides, and on limited occasions audio and video tapes, teleconferencing, and maybe even closed circuit television.

Analogous applications of digital means would easily replace every learning object in the student's possession, except the textbook at least for now, with a laptop computer and a integrated software package.

All the items which faculty distribute on paper may be digitized and uploaded to be downloaded by students, distributed as E-mail, or just passed around on a disk during class. The classroom may have network connections for all present otherwise, students would be responsible for securing digital material prior to class.

For lectures, faculty have the option to use digital means to integrate text, graphics, sound, movies, and animation in a controlled presentation and show it in class.

Further reliance on technology offers several new teaching tools. Groupware is software that allows a class to simultaneously contribute to a text based discussion.This has direct application for design in the area of programming with client and user group participation in "brainstorming" sessions. Conferencing software or subscribing to a class sponsored news group would provide a forum for discussion out side of class.

All course work brings with it a body of knowledge which is rudimentary, boring, but essential for understanding. These concepts need continual review and eat up valuable class time. Isn't this a perfect task to give to computers? By

establishing interactive learning modules, faculty will be afforded the time to discuss relevance. Although involves a considerable "first time" investment by faculty, there may be an opportunity to publish or share modules with professors at other institutions.

Authors and book publishers will welcome proposals by faculty who use their textbooks to produce companion interactive learning modules. History, structures, environmental control systems, construction detailing, and other applications surely fit this description. Because of storage capacity, CD ROM is the likely choice for media.

Simulation software provides students with a critical tool. Cause and effect are demonstrated in a way no lecture can duplicate. Availability of this type of software is only limited to the imagination of faculty. These packages range from games given a pedagogical spin to pure engineering applications. Nicholas Negroponte in a recent article in Wired magazine entitled "Build a Frog Don't Dissect It" is skeptical about interactive learning modules but enthusiastic about simulation software because of its ability to engage the student in active learning not drill and practice.[19] At times, drill and practice are the only ways in which information is driven into the memory.

The Internet also offers the possibility connectivity to information, people, and groups to line by text and or sound and or image form remote locations. Conditions for this may

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[19]Nicholas Negroponte, "Don't disect the frog build it," Wired, (July 1994), 176

develop in the near future. Costs of travel have made physical visits by those who are certain to add to the learning experience quite rare. Digital networks and satellite links are making these experiences possible again.

Since this section on curriculum deals with students and faculty in more typical seminar and lecture context. Students may have brought many "global-skills" with them to the university. The foundation course concentrates on traditional and digital means to architecture, with a major goal of building "vertical-skills" (directly related to the design process). There will also be content which redirects existing "global-skills" toward the design process, architectural lecture and seminar situations. Exceptions happen with the crossovers between the studio setting and the and technical courses requiring sharing of graphic material. Technical courses using specialized "simulation-software" will find it necessary to train students within the class. This software may be distributed to students by disk or network.

The Future:

And after it is all said and done, there stands the future! It is in the future where we can make amends. This thesis wastes much paper pointing out the muddle which architecture is in regarding its handling of digital means and information technology. Architecture has much catching up to do but not so in the area of the future; that's a different story. Dialogue about the future can start today and architecture will be right in step. History is a standard offering in architecture schools and much can be learned by these retrospective views to the past. It is hoped that this discussion will make a case for similar attention paid to the future.

Chapter Two illustrates just a few of the countless triumphs of information over material. Computers allowed this information to dematerialize further to a point where it exists as bits not atoms,[20] allowing it to be transmitted not mailed.

As architects scratched their heads prior to the deployment of digital means, they had only to observe early architects, who found it easier to speculate on paper than moving masonry into different locations,to guess that this would happen. The time and energy they saved here allowed thought to intercede and architecture was conceived out of building.

The computer has facilitated the next episode in a chronicle which started before Imhotep. Soon we will be contending

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[20]Nicholas Negroponte, "Bits and Atoms," Wired, (January 1995), 176

with another paradigm shift where space and form themselves will dematerialize, now only manifest as carnival attractions or the 3-D walk-throughs. This fantastic future to be played out in cyberspace will combine information technology with virtual reality. This can be considered a direct continuation of the space-altering telegraph and the time altering phonograph record.[21] The Internet today in some ways is just as primitive as those two firsts. Considering today's replacement for yesterday's gramophone, you may be close to imagining Internet developments which are not far off.

The oxymoron, science fiction, is the forum where the future is conceptually created. As a base for action science fiction is destined to become science fact. The author must commend the futuristic planning committee of his mother's 1933 Annual Spring Banquet at the Public High School in McIntosh, MN for picking the theme "Fly Me To The Moon". Thirty six years and some two months later, that phrase, born of Jules Vern, dramatized by Buck Rogers and romanticized in song by Frank Sinatra became fact. Star Trek has raised our expectations, pointed us in directions of discovery, and given us 'handles" to hang on phenomena which we end up discovering sooner or later.

If the future is not a part of architecture, architecture may not be part of the future.(bumper sticker alert) There are others who would be more than happy to provide design services for cyberspace. Today there are firms (some archi-

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[21]Michael Benedikt, ed., Cyberspace: First Steps (Cambridge: The MIT Press, 1991), 9

tectural) who develop "big picture" concepts, and leave "regular" architects to split the fee which remains with their consultants to provide for the "pragmatics" of the project. In cyberspace, "pragmatics" will be under the control of computer professionals, and even Walt Disney animators have the expertise for the big picture. Yes, space and form may degenerate into mere entertainment or a media run event. The commissions which architects enjoyed for designing public facilities may evaporate as buildings become hollow shells for computers which collect, manipulate, and communicate information required to operate cyberspace. Is this starting to sound familiar? Isn't this process what architects have called design?

What becomes clear for the future we are now facing today? Just as this thesis makes an argument for the continuation of traditional means in the face of digital means, the future's dilemma will pit traditional space and form against digital space and form.

Inactivity on the part of architecture schools regarding concepts like cyberspace and virtual reality will spawn a future thesis to be penned with parallel development to the one you are reading. Perhaps its author using a "find-then-change" command in some future version of a MSWord© will find "means" and change it to "space and form".

The stakes for the profession will be much greater. Instead of a discussion developing an information age attitude, it will be a desperate sink or swim struggle for the survival of reality itself.

Like it or not, we are several steps into virtual reality, space and form are still traditionally material based (kind of) but it has become highly symbolic and in that way, dematerializing and quickly becoming information based. To realize this, experience a franchised food establishment at several locations, then consider other people who are at this same place also ordering "combos" at different locations. This "placelessness" threatens to smother the uniqueness of a place with sense numbing images of corporate origin. History can raise our awareness of what has happened. Paying attention to the present can draw attention to what is happening. Speculating on what the future has in store may allow us to control what will happen.

This thesis calls for the continuation of traditional means and its fusion with digital means for architects, students and faculty. Its basis is rooted in the fact that traditional means are still an efficient worthwhile activity.

The future parallel thesis will call for the continuation of traditional space and form and its fusion with digital space and form for society. Its basis would be rooted in the fact that traditional space and form although by then not efficient will be worth having, note that the stakes are considerably higher.

In comparing this thesis with the seeming absurdity of the future thesis shows the importance of clear decision making when and if the occasion arises. The hype of the Internet, cyberspace, and virtual reality clouds this issue today and if a conscious effort isn't made to keep dialogue between

students, faculty and professionals open, ignorance is bound to prevail. If we indeed follow in our past footsteps regarding the digital space and form of the future, we risk the chance that this future technology may, as with the panda's thumb and the qwerty keyboard, not be the best.

CHAPTER FIVE

As this thesis draws to a conclusion, the reshaping which was promised by it's title will come into sharper focus. There is a natural to generalize about moving targets like technology. Including detail in any form adds clarity to the present but limits future relevancy. This risk is diminished since how architecture schools respond now is crucial.

This chapter reviews hardware/software issues requiring administrative decisions, details a foundation course which will introduce traditional and digital means, explore fusion of the two, and develop an important Information Age point of view. Finally, the existence of a network opens the way for developing of a virtual school of architectures can coexist with real ones.

The conclusion is a call to action. Architecture schools have waited long enough to take action against this ignorance which has caused so much fear. Rights have been violated, freedoms have lost. Academia must face up to its responsibility in the area of digital means and information technology, as well as respecting those traditional means which have been the essence of the profession from its start.

Some Pragmatic Considerations:

For the author of this thesis, it has been refreshing to write about computers in a "platform-neutral" way. The senseless anxiety and alienation which has transpired between computer advocates and those who would rather not use digital means can only be eclipsed by the rivalry between users of the available hardware/software platforms which are available.

The wide variety of hardware/software combinations suggests that there is a wide variety of consumers for these products. Part of digital "ownership" is finding one's own path through the maize of possibilities. The idea that computers have fundamentally different uses depending who is using them suggests a wide sampling from this variety.

Architecture schools, however, must make concessions to a degree of conformity. Faculty will encounter situations where they are called to assist students with hardware/software problems which develop. Courses which utilize digital means also require a firm commitment to specific software applications.

Standardization here seems to be the most practical solution and if it were not for the tremendous outlay of capital borne by the student, administers would be perfectly within their rights to dictate the combination they saw fit. Relative platform freedom perhaps is the logical solution. To maintain this stance, however, only software which is available for multiple platforms should be considered. This broad

generalization is sure to have exceptions and critical evaluation of appropriate software is almost sure to turn up products which are limited to a single platform. "Hard"and "soft" solutions are available to allow single platforms to emulate and operate software from other platforms.

It would be easy to adopt the narrow, single answer solution for the hardware/software question. To date, this has been the response of the profession which has almost universally picked the single hardware/software standard.

Normally, having a single answer to a problem is very rare in architecture schools and practice. A design studio professor, for example, distributes a single design problem statement to an entire section of students and fully expects to receive as many solutions as there are students. The completion of the problem precipitates a free and open dialogue between the professor, visitors and the students themselves about the merits of these solutions. Engineers on the other hand practicing in a "comfortable," conservative fashion, stress the obvious, single answer carried out to a prescribed number of decimal places. Does the engineering professor handout as many different problems as there are students?

Architecture schools could opt to default and choose the industry standard hardware/software platform, without question. But debate on this point is more characteristic of how architecture schools approach other issues. This is the debate which should have taken place at least a decade ago in these same schools prior to digital deployment which ensued out of ignorance.

Digital means usually precipitates discussions which dwell on the latest hardware specifications and software versions, and tracking the best available products. The budget per student for a standard hardware/software platform aims must aim at a lower level and denies literally copying the typical workstations of practice. Remember, the focus of digital means in practice is on producing architecture. This is quite different than academia's goal where students are learning about being architects, and faculty are teaching this to students. Literally duplicating the workstation of practice has been the approach taken by technical schools use whose primary goal is building skills.

Empowerment mandates that architecture schools, faculty and students share responsibilities. A prime reason for student lease/purchase of hardware/software platforms was based on the assumption that technology continually develops better products at more affordable prices. Hardware/software improvements stress issues such as speed, storage, and a plethora of new features which trickle down from price point to price point until they are affordable. Software is also being continually updated. Just the fact that software is released by industry with "bugs" before it is perfected is reason enough to purchase it as often as possible. Each year of empowerment will expose students the benefits of new technology, more features and upgraded software.

In the past, institutions took direct responsibility for purchasing hardware/software platforms. Budgets never allowed for enough computers for each student and the thrill experi-

enced by students in the first year of use however was not generally echoed by students several years later. There was dissatisfaction with this aging hardware because it lacked, memory, speed and storage capacity for efficient operation of continually updated software. The necessity to amortize expenditures usually resulted in the hardware being used far beyond its prime.

Empowerment initiatives make other demands on institutions such as "networking" their facilities, providing peripherals for student use, and assuring the entire digital experience is a success. These items and issues are not so dependent on incremental advances in technology. A primary items is the installation of a network with bandwidth wide enough for the quantity of users and bits to be transmitted. Along with the network is a related need for intuitive, easy to use communications software which can facilitate the constant uploading and downloading of software and documents.

The faculty is responsible for delivering an educational experience which coordinates digital means with the subject at hand. The focus here is on what can actually be done digitally. Since hardware is task independent, software choices are elevated in prominence. Software must be quick and easy to learn to allow time for course content.

The cryptic syntax which was required to use computers in the past has all but vanished. Graphical User Interfaces (GUI's) today have become the standard means of operating computers on most platforms. This icon driven approach to computer operation allows users to navigate computers with

ease even if they have had no previous digital experience. This development has greatly shortened the digital learning curve. GUI's also liberate the user's memory since command options are always in view.

Competition between traditional and digital means first arose when there were editable digital ways to accomplish traditional tasks. The analogous behavior of hardware / software platforms which mimic the reality of traditional means accounted for the overwhelming success of digital means. Many real computer tasks (only slightly analogous) also exist. These may seem to have surface similarities such as spread sheet software to ledgers but no ledger will automatically perform the mathematical functions which spread sheets do. New and innovative applications where automation is central to the task are the real strength of digital means.

Software brings out multidimensional qualities from computers. Students enter the university with the skills to operate broad "global" applications. Software of this type is mandatory since this breath will encompass architecture. As these students major in a particular field of study, they encounter narrower "vertical" applications.

Just how narrow should the focus in architecture schools be? The reader may be familiar with the following two common responses:

"Yes, you draw pictures of buildings?" has been the typical reaction to questions by the lay person when being told that one was studying or was indeed an architect.

"Then you use CAD?" has been the typical reaction to questions by the lay person when being told that one using a computer in architecture.

To uninitiated lay people, architecture is simple and predictable. How that idea came to be is not a subject for this thesis. What is important here is that architects (and would-be architects) at least know what they do. Yes, faculty, students and professionals do draw buildings. The real questions here is, do they only draw buildings? If the answer to that question were yes, the narrowest of vertical software application would indeed be appropriate.

Should students in the learning mode only be privy to "black box" software which prompts choice after choice, addressing elements from footing size to roof slope, with the final product being a building which draws itself? Will this software be so pragmatic as to stifle the creative spirit of students? Should the use of digital means be a substitute for complete understanding?

"Generic" non-building specific vector, object oriented, and parametric solid based software puts imaginations of students to work allowing creative involvement and yielding understanding. Traditional means for the most part didn't place any limits on what could be drawn using them.

Software is available in two fundamentally different forms. It can be purchased as a "stand alone" product which does one task or as an integrated product which functions for several tasks. Integrated packages are compact, economical, but may compromise performance by trying to accomplishing so many tasks. Global integrated software offers a wide range of tasks including word processing, data base, spread sheet,

drawing & painting, slide presentations and communications all within a single package. These products are quite adequate for the purposes of students who are redirecting their global skills toward architecture.

Integrated vertical packages for architects and designers offer 2-D, 3-D, and perhaps a feature which allows a spread sheet function to be related to items represented graphically. This product may be adequate for what it does but lacks items like surface rendering ,shade and shadow casting, or the ability to make an animations. There are "stand alone" software products which may deal with each of these additional tasks. This requires some form of connectivity be available to foster writing and translating files to be imported and exported between different software programs.

When we consider the trappings which are associated with traditional means, quality became an issue too. Which of the following are packages which contain similar items do you think would be appropriate for beginning students?

Package One:

a Bic© pen, a yellow legal pad, paperback dictionary, a wooden pencil, a roll of trace, a scale, a triangle, a set of disposable tech pens

Package Two:

a Mont Blanc Pen©, Cranes Stationary©, an Unabridged Oxford Dictionary©, a platinum mechanical lead holder (these must be available somewhere), drafting linen, a mechanical drafting machine, jewel tipped technical pens,

That answer was obvious but if one were to consider digital

means, the tendency is to take software literally used in practice oriented toward Package Two above and run it on a lap top computer oriented toward Package One above. Yes, when considering traditional means, one can use crossover between the two packages above quite nicely.(like wearing tennis shoes with a tux, chic!) This may not be the case digitally. No matter what software venders say, extreme care must be taken to assure that the pairing between software and hardware is appropriate. It is far better to underutilize the hardware than to overload it. Don't outstrip the capacity of the hardware and the creative options of the student by choosing the "ultimate/black box" product.

Assumed elsewhere but not as yet discussed is the choice of "lap-top" computers for student use. There are many pragmatic reasons for this action including the obvious portability, related security benefits, and minimal power required which becomes important with entire studios full of them. For the most part, these models are available with similar specifications as their desk top counterparts. Several obvious disadvantages also come to light including size of display, poor cursor control, at times smaller than standard keyboards, and the increased price of miniaturization.

The important issue tipping the scales in favor of lap-top computers is the ease of setting them aside to enable using work desks for traditional means. This contributed to Mississippi State's School of Architecture's "lap-top choice" and continues to be a sound reason today. A student can bring the computer to the professor for review instead of requiring the

professor go to the computer. Thus maintaining a proper attitude between the computer and the human due, in part to this subtle level of control which can be exercised over them.

Portability enables students to bring computers to classroom settings, to libraries for research, and to their homes for productivity in peace and quite. Even remotely located classrooms themselves are easily networked through portable means for group investigations, software and information sharing.

The volatile nature of technology will make two years seem like a decade. Decision makers should carefully research hardware availability but retain flexibility for last minute changes. Platforms should be considered for simplicity of operation and connectivity. With a potential of hundreds of computers in use, there certainly will not be hundreds of technicians looming over student's shoulders to offer assistance. The campus computer center staff (a group that already manages hundreds of computers) may be able to contribute sound advice on this matter. The ease with which faculty and students are able to do what has been termed "plug and play" the various peripherals which are sure to be available is of great importance. Each computer needs to be equipped with a compatible network card to enable connectability. Eventually, campuses will network dorm rooms but to maintain off campus access to the campus network, modems are also an essential requirement.

Internal hard-drives should be large enough to partition into two "volumes." One "volume" to contain the school's

standard operating system and software combination and the remaining volume for student use. Having such a standard will greatly simplify problems.

To get a complete digital experience, students will need to rely on peripherals typically furnished and networked by institution. Larger video displays may be necessary, depending on the scale of the task. Architecture demands unique paper output requiring both large scale and color printers. Both scale and color have been available for traditional means and should not be denied for digital means. With time, the profession may move away from paper completely in favor of media which still retains its editable, flexible, and transferable form.

Availability of several peripherals make fusion possible. Scanners are a must for digitizing drawings, photographs, or other two-dimensional images. Slide scanners are also available for architectural faculty members who are notorious for taking slides in large quantities. Digital cameras varying widely in price and resolution eliminate the need for scanning by storing images digitally for downloading directly into computers. Video capture and sound "boards" can be installed within computers allowing digitizing video images and sound for manipulation with appropriate software.

Pressure sensitive digitizing pads, some as small as a "bar-napkin" (the classic conceptual media of many architects), paired with extremely analogous software allow watercolor, pencil, marker and many more "virtual implements" to be naturally and directly inputted. The wireless stylus

included allows a the freehand input with the control of a real pencil and the pressure sensitive feature allows the action of a brush. These items are presently a phenomenal success in Japan where keyboard input has been less than satisfactory for writing Kanji's enormous quantity of characters. Historically, pencils evolved out of necessity due to the awkward, painful experience of writing or drawing with a lump of lead or charcoal.[22] The parallel here between wireless stylus on digital pad and the mouse is uncanny.

Architecture schools will find out that what started as an initiative for empowerment will continue to build at ever accelerated rates. This paradigm shift is not unlike the struggle all of us have experienced over the years in deciding the appropriate media which music should be played and stored. Consider the transformations from cylinders, 78's, 45's, LP's,reel to reel tape, 4 track tape, 8 track tape, cassette tape, Compact disks (CD's), DAT tape, and Micro CD's. What will be next? Buying the "hardware" used to play those many media was usually only the beginning expenditure where "software and additional enhancements soon dwarfed that initial purchase. This is sure to be the case for architecture schools as time passes.

Many questions will arise after empowerment has been initiated. This will be a period requiring additional expenditures for input and output devices. Software needs will be voiced by faculty who have caught on to what's happening.

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[22]Henry Petroski, The Pencil (New York:Alfred A Knopf, 1990), 27

Increasing faculty use of digital means for course presentations will prompt need for software and additional projection devices. Interactive multi-media "courseware" for students will necessitate the need to press and play high capacity CD-ROM media.

Foundation Course:

Course development is the acid test of reshaping curriculum. Here, goals, objectives, precepts and policies are delivered to students. A foundation course will develop awareness and skills needed to manage architectural information. Foundation instruction would bring all students to a level where they understand both traditional and digital means in preparation for their participation in design studio and the other required courses within and outside the department or college.

The broadening of the course based on an information model will concentrate on seeking, solving and showing, or gathering, manipulating and communicating information which is the essence of the service-oriented profession of architecture. When one examines the options which humans have at their disposal, on the surface the range seems limited to thinking (internalized) and acting (externalized). In broadening, we discover, many forms of thought and action. In teaching the traditional graphics course, just calling it "graphics" only suggested a 2-dimensional product which at times would be called upon to represent objects in 3 -dimensionally.

Action even as it relates to design communication is a great deal broader than this. Calling into account, speaking, listening, composition of words, behavior, as well as drawing and drafting. Expanding beyond communication to the other information-related activities seeking and showing demands additional forms of thinking and acting.

Many opportunities for broadening will only involve noting the connections to architecture since students have been honing many of these "global" skills for years. The initial need is for students is to develop eye hand coordination, a sense of visual literacy, and graphic expression. Here, a parallel develops between traditional and digital means since students bring digital experiences from earlier exposure and need to have those experiences redirected toward architecture too. Finally students need to relate architecture to the Information Age attitude of seeking, solving and showing within the context of the design process will expose students digitally to doing familiar tasks in a design directed way as well as new exposing digital tasks they were just introduced to through traditional means.

The foundation course will in as complete a way as possible demonstrate traditional and digital means allowing students to seek, solve, and show. To cover so much course material, a strategy of primary and secondary exercises will be established. For example, students are able to write but should be offered the opportunity to do this in the context of architecture. Although this is a thoughtful endeavor, it can be done in conjunction with a more major task. Students can also speak, combining this with showing graphics they have produced gives insights into presentation. Again this can be accomplished with another major exercise.

The goal of this thesis clearly states that the past is important as we deal with the present and anticipate the future. Traditional means are still valid, active tools in

architecture and still need to be represented vigorously. It is also obvious that empowerment requires that students be introduced to digital means.

What is missing here is the notion of fusion between the two. Dividing the foundation course into two discrete parts sends a message to students that the traditional and digital means not to be related. Having two instructors teaching the course would prove to the students that a single person will be either "traditional or digital". The ideal will align both traditional means and digital means into a single course series. Students will discover methods concurrently through digital and traditional means. By opening the course up to both means, one is able to rise above provincial attitudes which have divided them in the past.

Fusion skills that speed up traditional means and humanize the digital means are what really practice is waiting for in architecture school graduates. Creating ambiguity questioning where an image started adds excitement to those numbed by character less plotted output. Fusion explores what can be done through the combination of traditional means and digital means using peripherals and software which practice has yet to discover.

Fusion is manifest in countless forms. Digitizing anything for example enables unlimited scaling of images permitting smaller more intimate output or making images the size of billboards. Adding desktop publishing software to the equation enables one to gather material from different sources to create a unified whole. This enables the architect to pub-

lish, distribute copies and literally sit with the client/ users instead of standing removed from them pointing to an image which only a few of them can see clearly. There are many examples of established techniques within realm of fusion. Many yet to be developed by the students.

Taking fusion one step further offers students the option of working in the realm of multimedia. Our society has become accustomed to multimedia through television. Even when using digital means, architects persist in using paper in a pixel world.

Consider the demographics which schools of architecture encounter. They are overwhelmed by numbers of hopeful students in the first years from which only a small percentage are selected to continue. Limited number of faculty positions make is difficult to expose the multitude of first year students to much more than a lecture survey course whose content gives broad initial exposure. Students usually enter architecture school completely ignorant of this their chosen profession and the built-in attrition rates naturally rise when students become more informed. All students, even those with backgrounds from art to descriptive geometry, need substantial redirecting toward architecture.

When is the best time to introduce this foundation course which is assumed to be an academic year in length? One solution is to offer the first semester of the series during the first year concurrent to the second semester of the lecture survey course and the second semester during the second year concurrent to the first semester of beginning design studio.

A second solution is to offer both semesters during the second year concurrent to both semesters of beginning design studio.

These solutions suggest two quite different courses. The first solution although not ideal due to the number of students it involves and the fact that students don't have their computers may be the most realistic solution. To make a decision about their future in architecture, even these first students need exposure to the insights which accompany the skills of the foundation course. Many architecture schools require students to submit examples of their work for review as part of the process of admission into the program. These institutions it would seem have no choice but pick the first solution. Finally there are certain foundation course skills which students need to bring to beginning design studio (along with those computers). One possible way which the second solution could remain a viable option is to offer an abbreviated course embedded within the first year lecture survey course to increase awareness and accompany that inevitable sketch book requirement.

The first solution assumes a large class size during the first semester and smaller classes during the second semester. A majority of these first semester students will not enter the program, although there is a slight chance these students as future clients of architects will benefit from what they learn here, it seems to be a waste of valuable program resources. Empowerment is not in effect for first year students so access to computers will be limited to those

which exist on the campus. The first semester will therefore become a modified lecture format course with "compact" exercises administered by teaching assistants.

The first solution makes it necessary to shift course objectives from an seamless presentation of traditional means and digital means with fusion techniques and revert to a somewhat more segregated situation. During the first semester, traditional means will be the major objective and digital means a minor objective along with the redirecting of the students' existing traditional "global skills". Since the second semester occurs during the second year, empowerment has "dawned" and students have their computers. During this semester, digital means become the major objective and fusion becomes a minor objective along with the redirection of the students' existing digital global skills.

Foundation course material will be presented with an eye on the Information Age. This attitude will serve as a beacon to constantly remind students what, why, and how they are dealing with information. Students will always be appraised how the task which is being accomplished using one skill could be done in an alternate way. Connections will be drawn between the route which is being traveled and the optional ones arriving at the same destination. These skills will be developed through a series of exercises which cover in major and minor ways the content of the lecture and reading material.

Many texts exist as entire courses or "units" of interest which provide a wealth of material concerning specific aspects of traditional means. There are only several texts

which take a global non-software specific approach to digital means. Fusion has been approached in the past using different aspects which are referred herein as traditional means but there has been little published on digital fusion except for software specific books which deal with the obvious fusion related applications such as image processing and desk top publishing software.

Conceptually, the foundation course shifts from having an emphasis on "hows" to "whats and whys." This is difficult when the goal of this course to build these "how skills" in the first place. The result of this "posturing" allows a variety of "hows" to be proposed for each "what and why." As Bill Mitchell present dean of the School of Architecture at the Massachusetts Institute of Technology explained in a recent interview which discussed this idea of switching back and forth between traditional and digital means, "It's not an either or questions, the two are complementary."[23]

Successful development of a foundation course poses a unique juxtaposition between traditional and digital means. A full complement of tasks can be accomplished traditionally, but digitally tasks have been limited only to only what practice has used and not the entire extent available.

The "freehand," discussed as the thing architects cherished and continue to use for conceptual investigation, will be the focus the first semester. Drafting with instruments must be introduced because at times, successful freehand expression

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[23]Bradford McKee, "The New Deans List," Architecture, (February 1995), 127.

depends on principals and actual layout initiated through drafting. Model building for example requires precise measurement and perpendicular cuts (for latent modernists anyway). Models built using an unguided knife leave much to be desired.

The second semester will present exposure to 2-D and 3-D drafting. Architects need precise drafting especially for the closed knowing phase of design. Computers are well suited to accomplish these closed tasks should not be limited to them. This limit has become the standard default attitude of the profession. Reinforcing this attitude were the standard input devices of keyboard and mouse combined with 2-D and 3-D software which emphasized this precision to as many decimal points as the user requested.

The course however should expand beyond this default attitude to allow digital means to encompass wider possibilities needed for those open questioning phases of design. Input devices and software are now available at reasonable prices that add unlimited freehand potential. If the course can show parity between traditional and digital means as well as develop fusion between them many more options become available and professional autonomy is reborn.

The next section will be devoted to detailing the foundation course. Each semester will be introduced and their objectives and schedules will be compared. A key to reshaping is to adjust the content of existing courses to reflect Information Age attitudes, the redirection of global skills, and the promotion of fusion through example and exercise.

Foundation Course:
First Semester Introduction

This course will be offered in the first year for students not yet admitted into the architecture program. Due to the large number of students enrolled the course will consist of a series of lectures conducted by faculty members and labs officiated by teaching assistants.

The course will be structured in a way which follows the path of information through the design process. This process will be divided into three phases seeking, solving and showing. Lectures and exercises will divide coursework into three distinct parts noting crossovers where they occur. The course will emphasize to **what** is being done, **why** it is being done, and **how** it is being done. Concentrating on these action verbs, will make connections with the variety of "hows" which are available using traditional means, digital means and fusion of the two.

This course will develop visual literacy through introduction of freehand drawing skills, first stressing open seeking actions; inquiry, questioning, observation. This is the portion of the design process is open to possibility.

The second part of the course stresses open solving actions and spans the questioning and knowing phases of the design process. Traditional skills are still primarily used by practice for these conceptual explorations.

A third part of the course stresses solving by introducing those traditional graphic conventions developed for archi-

tects to make the leap from concept to reality. Entering this realm is to predict the future which is what differentiates the service architects provide from those of other professionals like attorneys who examine the past and doctors who examine the present. These tools drawing use the two dimensional medium of paper to understand by orthographic projecting

Course Goals: Developing Visual Literacy
Facilitate Graphic Expression

Major Objectives: Traditional Means

Minor Objectives: Digital means
Redirect existing traditional skills toward architecture.

Suggested Texts: Freehand Graphics by Martha Sutherland
Keys to Drawing by Bert Dodson
Visual Notes by Norman Crowe and Paul Laseau
Freehand Perspectives for Designers by William Kirby Lockard
Architectural Graphics by Frank Ching
Graphic Thinking For Architects and Designers by Paul Laseau

Tools: The obvious assortment of traditional tools to accomplish a variety of explora tions.
Purchase of computer diskettes for trips to use fuse digital means.

Foundation Course:
Second Semester Introduction

This course will be offered in the second year to students who have been admitted into the architecture program. It will be divided up in sections of about twenty five individuals with a series of joint lectures conducted by faculty members and labs within the design studio conducted by faculty with help from teaching assistants.

As with the first part of this course, it too will be structured in a way which follows the path of information through the design process. This process will be divided into three phases seeking, solving and showing. This course will concentrate on action verbs, and make connections with the variety of "hows" which are available using traditional means, digital means and fusion of the two.

This course will stress using digital means for communication and finding information. Students will be required to obtain accounts on the campus computer network thus establishing Email addresses and a means a system of protocol will be established allowing students to download and upload information to the network.

The second part of the course stresses open solving actions: Global skills will be redirected toward architecture and faculty and students explore ways to loosen up the computer to allow it to be used in more conceptual ways.

A third part of the course stresses solving by introducing those digital graphic conventions developed for architects to

make the leap from concept to facilitating reality through communication with project decision makers and finally with those who will build it. Since these tools don't naturally exist on paper, alternate ways of presenting information will be explored. Links will be established between traditional and digital means and the subject of fusion will be discussed in depth.

Course Goals: Develop a relationship between architecture and the Information Age
Develop a sense of professional autonomy in their use of traditional and digital means.

Major Objectives: Digital means

Minor Objectives: Fusion of Traditional and Digital Means
Redirect existing digital skills toward architecture.

Suggested Texts: Digital Design Media by William J. Mitchell & Malcolm McCullough
Design over Media by Mark von Wodtke
Designing the Future by Robin Baker
The Reasoning Architect: Mathematics and Science in Design by Garry Stevens

Suggested Student Owned Software:
ClarisWorks©, Upfront© (MAC&WIN)
MiniCad©(MAC) or Graphsoft Cad©(WIN)

Suggested Schools Owned Software:
PhotoShop©, PageMaker©, Director©
Strata Studio Pro©(MAC&WIN)

Foundation Course Schedule Comparison:

This side by side comparison shows suggestions for topics and *content* divided by semester and week. Skills are related to the appropriate design phase (seeking, solving and showing) that they occur. *Fusion exercises* linking traditional and digital means are also noted.

First Semester

Week 1:
Course Introduction
Traditional Tools & Your Freehand

Seeking & Solving:
Week 2:
Drawing what you see
not what you know.
Life Drawing of Self
Week 3&4:
Seeing the Difference
Finding the Difference
Noting the Difference
Observe, Record, Analyze, Annotate
Week 5:
Exploring the Natural Environment
Representing Contours & Vegetation
Week 6:
Exploring the Manmade Environment
Finding Plan, Section, & Elevation
Existing in the world.

Showing:
Week 7&8: *(Fusion Exercise)*
Tightening-Up Your Freehand
Introduction to drafting
Week 9&10:
Showing Space on Paper
Introduction to Perspective
Week 11&12: *(Fusion Exercise)*
Showing a Reality on Paper
Rendering Surfaces
Week 13:
Showing Light on Paper
Shade and Shadow studies
Week 14:
Creating Miniature Space
Model Building
Week 15:
A Unified Whole
The Presentation

Second Semester

Week 1:
Course Introduction
The Analogous Tool

Seeking & Solving:
Week 2:
Written & Verbal Information
Information by Research & Interview
(One Dimensional Media)
Week 3&4: *(Fusion Exercise)*
Loosening-Up Your
Tight Computer
Doing conceptual tasks on computers
Week 5:
Inventorying a Place
Databases & GIS
Week 6: *(Fusion Exercise)*
Digital Trace
From Conceptual to Development
on Computers.

Showing:
Week 7&8:
2-D Orthographic Projection Sets
Finding Plan, Section, & Elevation
Week 9: *(Fusion Exercise)*
Making a Pattern
Model building outside computers
Week 10&11:
3-D Modeling
Modeling inside computers
Week 12: *(Fusion Exercise)*
Rendering Digital
and Traditional
Week 13:
Fly, Drive, or Walk Through
Motion, Animation, Movies
Week 14&15: *(Fusion Exercise)*
Digital Presentations
Multi Media

Digital Communication, Information Storage and the Virtual School of Architecture:

As a preface to a discussion of how digital means can augment the manner in which information generated within architecture schools is accessed and shared. First to set the scene with a short description of "Cyberspace" and the Internet.

Cyberspace, a word that originated from the pen of science fiction writer William Gibson in 1984, today is used to refer to the phenomenon created by the networking of the world's computers. Using the Internet, now a popular pseudonym for this network, is in a sense like navigating the parallel universe of Cyberspace.

Since so many computers are connected to the Internet, it has become important for communication, sharing information, research and countless other uses for government, business, academia, and the general public. The Internet has been around for since the early 1970's . As with the development of so many things including modern computers themselves, the network was established in this country for national defense. It operates in its most basic form with in a text based mode with text based commands.

The Internet was first used for "non-official" purposes by a core of enthusiasts mainly from the science disciplines. Increased public interest through the availability of commercial means of access and ever widening expansion of the network itself through government, academia, business, and the

general public have caused an explosion of users. The availability of electronic mail (Email) and "Online" forums called news groups surely contributed to this glut. The presence of these two features whose real function is communication and the sharing of information and personal views have the shared reason for getting involved and staying involved with the Internet.

The Internet has become the heart of the Information Age. Programs termed browsers have made the task of moving around the Internet easier too and as with personal computers some now offer easy graphical user interfaces. This once text based system has with the proper bandwidth capable of opening most digital files with ease and suddenly visual displays, sounds, and movies are accessible.

It is not the intention here to become euphoric about these " virtual places" but to point out their existence and relevance to architecture schools which have already made a commitment to empowerment. The additional energy placed in "constructing" virtual schools of architecture in cyberspace within a context which already demands that networks be established is sure to pay lasting benefits.

On the simplest level, networking schools of architecture can institute a "paper less" policy. "Uploading" (placing information on network servers) would replace "handing in" and "downloading"(receiving information from networks) would replace "handing out". Student work of all kinds would be open to peer review through the network, changing the dynamics of who sees student work will improve its quality.

Faculty must take care to maintain the relevance of class room attendance since technology seems to remove reasons for being there.

Work produced by traditional means can be digitized simply through photography allowing drawings and models to be uploaded and downloaded to the network too. Students and faculty (and the world if Gopher, WWW or Mosaic format is initiated) with Internet connections can review the entire range of departmental teaching and learning (inputs and outcomes).

Communications and scheduling will become automated with the use of Email and scheduling software. The opportunity for correspondence between student and faculty has always been available but dropped dramatically with the advent of the telephone. With it's decline, came the loss of deliberate, thoughtful assembly of words and phrases and maybe a reduction of candor and thoughtfulness since telephone communication needed to be "at the tip of one's tongue" "at the spur of the moment". Email may resurrect those positive qualities since it is many times more convenient and faster than conventional mail. The practical aspects of being able to access the schedule of faculty members for students, administration and other faculty members opens opportunity for actual physical contact between them.

If actual contact is not possible due to proximity or expense, digital conferences, teleconferencing and long distance critiques some using old technology of the conference call and some using broad bandwidth made possible by fiber

optics to transfer real-time audio and video between remote locations. Architecture schools have already experimented with cross continent design problems linking the students and faculty of two institutions perhaps making one group respond to a site which is familiar to the other group. This is in a real sense preparation for modern workplace which promises to be global in nature having commissions, clients and consultants spread across the globe. Any experience which students receive relating to these new proximities of work will pay big dividends in their future practice.

Conclusion:

Forming a conclusion which integrates digital means and utilizes information technology for architectural education and practice is difficult. A specific conclusion communicates commitment but risks longevity. A general conclusion, on the other hand, appears to lack commitment but stands the test of time.

Any conclusion proposing change within professional or educational institutions or which appears to step on the toes of academic freedom will be highly politically charged. A hard-sell approach will get attention and offend, but a soft sell which sensitively approaches the issue with tact and candor and lets everyone involved off the hook will perhaps be ignored.

No one wants their work to go unnoticed especially for the above reasons. The title of this paper starts with the action verb "Reshaping" perhaps to suggest that the point of view here be transformed into policy. The author of this thesis didn't have to deliberate very long to choose a master thesis topic which had significance and direct application. This author positioned his call for action somewhere between straightforward and blunt. Now it is up to you, the reader, to act.

For those who think that academia's dive into the digital pool is still optional, please consider the following. It is now three decades after initial research and development adapting the computer into a "design aid" and one decade

after wide spread deployment of digital means in practice. It seems high time that architectural schools make a significant commitment too. Education has relinquished leadership in the area of digital design to practice and information technology to junior high school students.

We have an obligation to equip graduates with a knowledge base and attitude to practice in the Information Age. Continued denial of the computer is only elevating it to an unapproachable status. For the computer to be a real design aid, it must become as ubiquitous in architecture school studios as it is in practice.[24] Then the process of critically evaluating its potential can begin, a task which busy professionals haven't quite got around too. Only when the computer is understood for what it is, will freedom of choice return.

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[24]Cathleen McGuigan, with Maggie Malone, "Stone, Steel and Cyberspace," Newsweek (27 February 1995), 73

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Christopher Alexander, Notes on the Synthesis of Form, Cambridge: Harvard University Press, 1964.

Alexander, Christopher, "The Theory and Inventory of Form," Architectural Record, April 1965, 177.

Baker, Robin. Designing the Future: The Computer in Architecture and Design. New York: Thames and Hudson, 1993.

Michael Benedikt, ed.. Cyberspace: First Steps. Cambridge: The MIT Press, 1991.

Bronowski, Jacob. The Visionary Eye: Essays in the Arts, Literature, and Science. Cambridge: The MIT Press, 1978

Bunch, Michael A., "Core Curriculum in Architectural Education." Ph.D. diss., University of Houston. 1992.

Campbell, Jermery. The Improbable Machine: What the upheavals in artificial intelligence research reval about how the mind really works. New York: Simon and Schuster, 1989.

Huff,Chuck, Thomas Finholt. Social Issues in Computing: Putting computing in its place. New York McGraw-Hill 1994.

MacLeod,Douglas, "Architecture in the Computer Age," The Canadian Architect, February 1987, 41.

McGuigan,Cathleen, Maggie Malone, "Stone, Steel and Cyberspace," Newsweek ,27 February 1995, 73.

McKee, Bradford, "The New Deans List," Architecture, February 1995, 127.

Mitchell, William J., Malcolm McCullough. Digital Design Media: A handbook for Architects & Design Professionals. 2nd ed.New York Van Nostrand Reinhold, 1995.

_____,"Toward a Theory of Architecture Machines." Journal of Architectural Education, March 1969.

_____, "Don't disect the frog build it ". Wired, July 1994, 168.

_____, "Bits and Atoms". Wired, January 1995, 176.

Novitski, B.J. "Computers Go to School." Architecture, Spe-

tember 1993, 147.

Arno Penzias. Ideas and Information. New York: W.W.Norton & Company, 1989.

Roth, Leland M.. Understanding Architecture: Its elements, history, and meaning. New York: Harper Collins, 1993.

Stevens, Garry. The Reasoning Architect: Mathematics and Science in Design. New York: McGraw Hill, 1990.

ANNOTATED RESEARCH SOURCES:

Auger, Boyd. The Architect and The Computer. New York: Praeger Publishers, 1972.

Considering the date (1973), this book is somewhat speculative in nature, It seems to have good historical background material.

Baker, Robin. Designing the Future: The Computer in Architecture and Design. New York: Thames and Hudson, 1993.

A 'flashy' coffee table book which redeems it self by including all design fields not just Arch,,L Arch and ID. Contains a chapter on the bridging of the gap between art and science using computers.

Balestri, Diane P. ed.,Stephen C. Ehrmann and David L. Ferguson. Learning to Design, Designing to Learn: Using Technology to Transform Curriculum. Washington: Taylor & Francis, 1992.

The advent of affordable computing and telecommunications has allowed schools and colleges to maintain computer labs with appropriate software and peripherals which can serve as "design studios for a variety of disciplines". Included are essays by members of the Fund of the Improvement of Post secondary Education Technology Study Group.

Barry, John A.. Technobabble. Cambridge: The MIT Press, 1991.

The book is the story of the effects on technology on our language and society. This may only serve to help me use "Technobabble" myself.

Benedikt, Edward ed..Cyberspace: First Steps. Cambridge: The MIT Press, 1991.

Fact and science fiction concerning cyberspace and virtual reality. Full of speculation concerning this next digital frontier on par with Negroponte's Architecture machine of 1970.

Bronowski, Jacob. The Visionary Eye: Essays in the Arts, Literature, and Science. Cambridge: The MIT Press, 1978.

This book was in included due to a chapter entitled "Architecture as a Science and Architecture as an Art".The chapter concludes with the following: "In the intellectual revolutions of the past, architecture has

been a point of fusion: the most sensitive point at which new ideas in science and a new conception of the arts have crossed and influenced one another. If the architect is willing to make them one, by learning to live naturally in both, there will at least be fine modern buildings, and citizens wise enough to see that they survive."

Carrara, Gianfranco ed.and Kalay, Yehuda E., .Knowledge-based Computer-aided Architectural Design. Amsterdam: Elsevier, 1994.

The following quote from the preface restates the promise supported by hype from the late 60's and juxtaposed it with today's reality. "The focus on R&D in computer aided design, over the past 30 years has shifted back and forth from attempts to totally automate the entire design process to its partial support though drafting tools, from representing the properties of objects to modeling and visualizing their form, from the synthesis of design solutions to evaluating their specific performances"

The contributor of this collections of papers feel now is the time for a compiled search for answers presented in this volume. the papers were presented at a symposium co sponsored by the Italian National council for Research and CARTESIANA (a consortium of construction and software firms developing applications for the building industry)

Cooley, Mike. Architect or Bee? The human price of technology. London: The Hogarth Press, 1987.

The title poses a question about the dilemma of all who labor. Although not necessarily pertaining to architects or designers the broad issue questions the quality of technological assisted work.

Cross, Nigel. The Automated Architect. London: Pion Limited Publishers, 1976.

Design methodology meets the computer. A computer could solve a design problem if the problem was "computable".

Eastman, Charles M.. "The use of Computers Instead of Drawings In Building Design." AIA Journal March 1975, p.46-50.

An article which suggests a way to approach the design of a building when utilizing a computer. The work is

based on the use of the C-MU Building Description system developed at Carnegie Mellon University with funds from the National Science Foundation.

Evans, Christopher.. The Micro Millennium. New York: The Viking Press, 1979.

This book presents the Past / present / near future (which has past) and long termed future (now living) of the Computer Revolution.

Driscoll, Porter, Joseph Marzeki and Forrest Wilson.. " Architecture and the Information Revolution." Architecture July 1982, p.65-77

The article is a discussion about the changes computers will make in design offices and the effects of the forth coming information age on the field of architecture.

Greenberg, Donald P.,. "Computer Graphics in Architecture." Scientific American May 1974, p.98-106.

_____. "Computer Graphics in Architecture." Scientific American February 1991, p.104-109.

These Greenberg articles are noteworthy since reveal the a curious public the feats computers are capable of doing. Since they were written 17 years apart they also chronicle advances made.

Kennedy E. Lee,. CAD Drawing, Design Data Management. New York: Whitney Library of Design, 1986.

The purpose of this book was to present design professionals with practical techniques for managing CAD. The basics are presented in a understandable way. I am interested in the comparisons which are made between traditional and digital means.

Lorenzini, David. "First Steps in Computer Use for Smaller Firms." AIA Journal July 1974, p.38-40.

This article deals with the availability of MASTERSPEC program for architects. This is a thing which the profession takes for granted today however in 1974 it was not as simple.

Mathews, Walter M. ed.. Monster or Messiah? The Computer's Impact on Society. Jackson: University Press of Missis-

sippi, 1980

A collection of papers presented at a seminars on the topic "The Computer Impact on Society" funded by the Mississippi Committee for the Humanities as a part of the The Computer Impact on Society Project.

McCullough, Malcolm ed., William J Mitchell, and Patrick Purcell. The Electronic Design Studio: Architectural Knowledge and Media in the computer Era. Cambridge: The MIT Press, 1990.

Contents are a collection of papers presented at the CADD Futures 89 conference - a a gathering of researchers and teachers in the field of computer aided architectural design. the conference was jointly sponsored by MIT Department of Architecture and Harvard Graduate School of Design

The conference and now the book explore the gains and losses that came with the introduction computational techniques unto a practice where "shape" computations were carried out by hand using the simplest tools.

McIntosh, P.G. ed.. ACADIA Workshop "85 Proceedings. Tempe: The Association for Computer-Aides Design in Architecture, 1985.

This group is active today and there must other similar documents. "Dated" papers relate pedagogical theory and practice in architectural education.

Mitchell, William J. Computer-aided Architectural Design. New York: Petrocelli/Charter, 1977.

This book was published at a time when computer aided design was just becoming technically and economically feasible. The book suggests that computer aided design techniques will radically transform architectural practice due to the following factors:

1) basic research conducted during the past decade has established theoretical foundations
2) powerful and reliable software is available
3) decreasing cost and widening availability of computer hardware

This book was intended to be the practical introduction to computers "no detailed knowledge in programing is assumed" instead. "knowledge of elementary algebra and trigonometry should....be sufficient mathematical preparation"

The book has an extensive bibliography.

_____. The Logic of Architecture: Design,Computation, and Cognition. Cambridge: The MIT Press, 1989.

A rigors investigation of building form with a large dose of understated computer manipulation in an attempt to discover how architectural languages can be established. This book is broader than the subject of computers but shows exemplary utilization of digital methods.

_____, Malcolm McCullough. Digital Design Media: A handbook for Architects & Design Professionals. 2nd Ed.,New York: Van Nostrand Reinhold, 1995.

The authors state that "Future historians will mark the 2000 as the year by which the computer had become the standard means for accomplishing practical architectural, urban, and landscape design work." The book takes a hardware and software neutral approach concisely reviews the fundamental principles of computation. A vast source of bibliographic citations.

Negroponte Nicholas."Toward a Theory of Architecture Machines." Journal of Architectural Education, March 1969

This article was written on the occasion of publishing The Architecture Machine. Negorponte already seemed to understand the inevitable fate of the machine.

_____. The Architecture Machine: Toward A More Human Environment. Cambridge: The MIT Press, 1970

This book is visionary since many of the concepts presented were not and still may not possible.Negroponte extrapolates into the future based on experience gained in the MIT Media Lab. Published at a time when digital means were the subject of research at several Institutions of Higher education. (not available to the profession)

Book reviews and interviews with Negroponte prompted the first computer/design articles in design practice and education journals.

_____. Soft Architecture Machines. Cambridge: The MIT Press, 1975

The book contains experiments preformed by the Architecture Machine group at MIT from 1968 through 1972. This book is an "epilogue" to the Architecture Machine written in 1968.

Negroponte states in its introduction "All too often

we spend out time making better operating systems, fancier computer graphics, and more reliable hardware, yet begging the major issues of understanding either the making of architecture or the making of intelligence"
The appendix deals with several aspects of teaching research related to computers and design.

Parkman, Ralph.. The Cybernetic Society. New York: Pergamon Press Inc., 1994

Written to give perspective to the study of man's role in an increasingly technological environment. It will provide good historical context.

Pask, Dr. Gordan and Susan Curran. Micro Man: Computers and the Evolution of Consciousness. New York: Macmillan Publishing Co. Inc., 1982.

This book is about the relationship between humans and computers. Pask states "We humans have shaped computers, and now computers are shaping us and our environment."

Radford, Antony and Garry Stevens. Cadd Made Easy: A Comprehensive Guide of Architects & Designers. New York: McGraw-Hill Book Company, 1987.

There is an honest attempt to illustrate the advantages and problems which practice is presented with upon instituting a digital office. Published at a time when a majority of design firms were making digital decisions. Included is a very extensive bibliography it even includes M McLuhan!

Robbins, Edward. Why Architects Draw. Cambridge: The MIT Press, 1994.

Robbins theorizes that drawing has social and cultural uses and continues to develop an argument for this.This book contains interviews with 11 architects about why they draw. Humble and opulent examples of drawings are prevalent. Short of my interviewing 11 architects around the world about drawing, this provides me with the next best thing.

Sieghart, Paul, Microchips With Everything: The consequences of Information Technology. London: Comedia Publishing / Institute of Contemporary Arts, 1982.

Essays of this volume were based on contributions made at a series of five seminars entitled IT's Consequences: Social and Political Implications of Information Tech-

nology organized by the Institute of Contemporary Arts, in July of 1982.

Schmitt, Gerhard. Microcomputer Aided Design for Architects and Designers. New York: John Wiley & Sons, 1988.

The author's "aims to remove the unnecessary mystique surrounding the use of computers for architects and designers". Following are contents keywords: TRADITIONAL DESIGN APPROACH, basic skills, representation, manipulation,INNOVATIVE DESIGN APPROACH, abstraction, discovery, creativity, evaluation. The overall appeal of the book is low but I will give it a change since the subject matter parallels 'curriculum building'.

Stea, David."Mediating the Medium." , Journal of Architectural Education, January 1968 p.7

This article discusses simulation and the resaons which on would do it.

Stevens, Garry. The Reasoning Architect: Mathematics and Science in Design. New York: McGraw Hill, 1990.

Stevens makes a case for elevating the influence of mathematics and science in architecture. He states "It is the aim of this book to show that although architecture is usually thought to be the product of acts of inspired creation, it is also the product of acts of inspired reason..." Stevens chronicles the tension and split between art and science in architecture.

Telcholz, Eric.. "The Biography of a Remarkable Tool." AIA Journal, May 1980, p.64-65

Retrospective article past quotes of such notable figures as Charles Eames , R Buckminster Fuller, Chrisopher Alexander and W J Mitchell regarding the utilization and effects of computers in design.

Tufte, Edward R.. The Visual Display of Quantitative Information. Cheshire: Graphics Press, 1983.

_____. Envisioning Information. Cheshire: Graphics Press, 1990.

Tufte's books "escape flatland" by illustrating the past and present ways which information has been displayed graphically on the printed page.

Wendle, Ronald W.. "Some Cautions on Computers." Architecture September 1983, p.77.

Written at a time when the profession is on the verge of entering the age of digital design. Wendle states, "They *(computers)* are useful (and expensive tools, not practice panaceas".

West, Suzanne. Working With Style: Traditional and Modern Approaches to Layout and Typography. New York: Watson - Guptill, 1990.

One of the first books that recognized that the computer was enabling (empowering people) to do things which they didn't completely understand. The subject here is desk top publishing software eliminated professional involvement in office generated publishing. West cites two styles traditional and modern relating the proper application of each. An unselfish effort in trying to make the world more beautiful.

Willis, Beverly. "How a California Firm "Grew Up" with a Computer." AIA Journal, January 1976, p.48-64.

An architecture firm examines existing software available on a time share basis, installs a terminal and has the use of a computer for a nominal rate. The firm grows and prospers due to the computer.

Wurman, Richard Saul. Information Anxiety: What to do when information doesn't tell you what you need to know. New York: Bantam Books, 1990.

Unique book which delivers information in ways which books have never done in the past. Wurman makes an apt appraisal of the *Information Age* which in my opinion designers have never really understood.