ABSTRACT

BRINGING IDEAS BACK TO THE EVOLUTION OF DESIGN

by
Ayça Tüzmen

This thesis is an exploration into the evolution of design. It attempts to develop an awareness of the effectiveness of what we do as designers and users to improve design. To achieve this purpose, it elaborates on some of the implications of paradigms which have emerged in design evolution. It presents some of the evolutionary theories and their analogies. These theories and analogies develop a view of design evolution - a conception of design as a process which moves from a lower to a higher state. With this conception, concern is directed at the identification of past and current design processes. An attempt is made to elaborate prescriptive and descriptive theories of design studies. For the identification of the higher state of design, the characteristics of an "ideal" design are elucidated.

The broader aim, to which the author hopes this thesis will contribute, is to design a process (the order of actions) which helps achieve the ideals of design. This study brings in ideas on how to achieve the ideals of design. The purpose is to inquire into the essence of the ideals behind the process which plays out the ultimate freedom in design inquiry through design education, practice and theory.

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by
Ayça Tüzmen

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APPROVAL PAGE

BRINGING IDEAS BACK TO THE EVOLUTION OF DESIGN

Ayça Tüzmen

Dr. David L. Hawk, Thesis Advisor — Date
Professor of Architecture and Management,
New Jersey Institute of Technology

Glenn Goldman, Committee Member — Date
Associate Professor of Architecture,
New Jersey Institute of Technology

Dr. William R. Spillers, Committee Member — Date
Professor of Civil and Environmental Engineering and
Chairperson of the Department, New Jersey Institute of Technology

BIOGRAPHICAL SKETCH

Author: Ayça Tüzmen

Degree: Master of Architecture

Date: May 1996

Undergraduate and Graduate Education:

- Master of Architecture,
  New Jersey Institute of Technology, Newark, NJ, 1996

- Bachelor of Architecture,
  Middle East Technical University, Ankara, Turkey, 1993

Major: Architecture

This thesis is dedicated to my father Yücel,
my mother Şengül ,
my sisters Aygül and Aytaç,
my grandmother,
Mindi and
Cihan.

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TABLE OF CONTENTS

Chapter Page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Human history has seen a succession of cultures - each incorporating a path - come to life, grow and die. A dynamic view of the world recognizes the fact that humans grow - pass slowly into different states or conditions - and their state of being in the environment changes. Humans never stay in a stable equilibrium for a long time; they change, grow and evolve. When new values come into focus, or the physical milieu as we experience it becomes unmanageable, the human system seeks to balance out the ensuing instabilities by adjusting all aspects of the human system [Jantsch, 1975]. With a quest to balance out instabilities, humans constantly modify their environments.

The realization of the existence of constant change in our life introduces these questions:

- *What can we know about the future?*
- *Is it going to be better than it was or now is?*
- *Can we control or influence the future and by what means we shall negotiate with it?*
- *Need we always adapt, or can we change the future?*

Russell L. Ackoff defines four approaches to the future [1974]:

a) *Inactivists* are satisfied with the current state of world. No action is felt to be necessary or possible for changing the present.

b) *Reactivists* are not satisfied with circumstances as they once were. They try to unmake the past by avoiding new changes which they call "the undesired".

c) *Preactivists* are not satisfied with circumstances as they are now or once were. They opt to predict the future and prepare for it.

d) *Interactivists* are not satisfied with the current or past circumstances. They want to invent ways to bring a desired future into existence [Ackoff, 1974].

The underlying philosophy in this study depends on the validity of the method in Ackoff's fourth approach. The author's bias for the validity of interactivism comes from a belief that humans have the ability to improve the environments in which they live. Evidence proving this is seen throughout the history of humankind where human beings have engaged life and changed it with technology. They looked for problems to solve and fit what they found to their solutions. Jantsch's conception of what we do or can do as humans is presented below. He says:

> "We are neither the manifestations of random fluctuation, nor the dumb children of some unpredictable god; we can indeed shape our own future and the course of evolution - if we flow with the stream, if we *become* the stream" [Jantsch, p.297].

This study is based on Jantsch's belief and is written for those who are interested in what they can do via individual or group efforts to improve the human condition. This work is to contribute to studies that seek to evolve - become better - and to find ways in which we can achieve a more desired state.

The things that people are satisfied with or desire are inputs that one would be glad to have. What makes people satisfied or not satisfied are primarily the decisions that they make and the consequences these decisions bring. Decisions are the main reasons for satisfaction or dissatisfaction with our life, with others, and with the environment.

Design is a kind of decision making, and is one of the many reasons for satisfaction and dissatisfaction. A design represents a series of decisions. However, it is not any set of decision, but decisions desired by the designer, client, or users.

With a recognition of the importance of design as of the many influences on human satisfaction, the contents of this thesis are to contribute to achievement of more desired futures. This study, bases its success on the legitimacy of a particular world view rather than on particular facts. For the development of a world view, the study undertakes these activities:

a) elucidate an evolutionary process in design

b) envision a higher state of design,

c) design an evolutionary process,

d) speculate on future actions that would be taken to improve design as a whole.

Chapter 2 raises the question: *What is evolution?* By bringing evolutionary theories from biology and drawing an analogy between the evolution of organisms and of design artifacts, the chapter discusses evolution and evolutionary process. Illustrations of theories and analogies develop a view of design evolution - a conception of design as a process which moves from a lower to a higher state.

Chapter 3 raises the question: *What are the higher and lower states of design?* The chapter gives credence to the idea that if one knows where to go, it would help plan the way to get there. In this spirit, the chapter elaborates on the past and current state of design and identifies the lower and less desired state of design that we seek to change. It describes the destinations that:

1. have been designated in the past
2. are designated in the present
3. would be designated in the future

The work in Chapter 3 discusses the influences of previous design studies on the current descriptions and prescriptions of design. The accomplishments and downfalls of the current state of design reflect upon the relative characteristics of design ideals. An identification of design ideals clarifies the end state of the overall performance of a design system, and of the optimum interaction among its components.

Chapter 4 deals with the design of an evolutionary process. It asks: *What is required for the achievement of design ideals?*

Participation, idealization, planning and development of physical and social environments are a collection of activities that are required for the achievement of an "ideal" design. These are the attributes that can take us far beyond self-imposed constraints and limitations. They furnish us with the capabilities to think about and implement design ideals.

CHAPTER 2

EVOLUTION OF DESIGN

As Philip Steadman argues [1979], the subject of evolution was first discussed in biological circles around the early 1800s. The impact of evolutionary thinking has shown up in subjects like architecture, design, archaeology and ethnology around the 1860s. The theory of evolution in biology has impacted the theory of evolution as it relates to design. Almost all evolutionary concepts in design, like in social and cultural life, trace their ideas back to biophysics. In this spirit, this chapter presents an understanding of evolution through presenting the analogies made between the evolution of organisms and of design.

In his book "The Evolution of Design", Steadman examines the history of evolutionary theory and sets out to criticize the many analogies that have been made between biology and design. Steadman describes first Georges Cuvier's attitude towards evolution. Cuvier, a French anatomist, is the one who first brought to the study of life the objectivity and the empirical technique of the truly scientific theory. He believed strongly in the "fixity" and "special creation" of natural species. He regarded theories of the origin of species as meaningless metaphysics. Cuvier's theory took for granted every change as part of the beneficence of God's creation. He rejected the evolutionary view, but paradoxically prepared the way for evolutionary theories.

Unlike Cuvier some biologists believed in evolution and tried to explain the process and its stages. Amongst the many evolutionary theories, the most published and the most popular is Darwin. Darwin's evolutionary theory drew its inspirations from scientific observations of the methods used by animal and plant breeders to produce modifications in domestic species. In his publication of "On the Origin of Species by Means of Natural Selection" in 1858, Darwin described the evolutionary process. He argued that by the process of "natural selection", organisms continuously are trying to adapt and adjust to their surroundings. As Darwin explains, this goal is achieved by a series of adaptations, each generation contributing to support and further the main aim by a trial and error method. Steadman, in his explanation of the Darwinian theory, says:

> It is not forces from the environments which mould the organism from outside, but a series of spontaneous changes coming from within which are then 'tested' against the environment; those which constitute improvements, or confer greater fitness, are preserved." [Steadman, 1979, p. 75]

The essence of Darwinian evolutionary theory is that the process of evolution generates as large a variety as possible. Work from finite chains of local processes pull from different ends. By proceeding in multiple directions, large varieties are generated and their appropriateness or inappropriateness are tested against the environment. In this trial and error method, only a few of the attempts "break through" to higher states and result in progress (Figure 1).

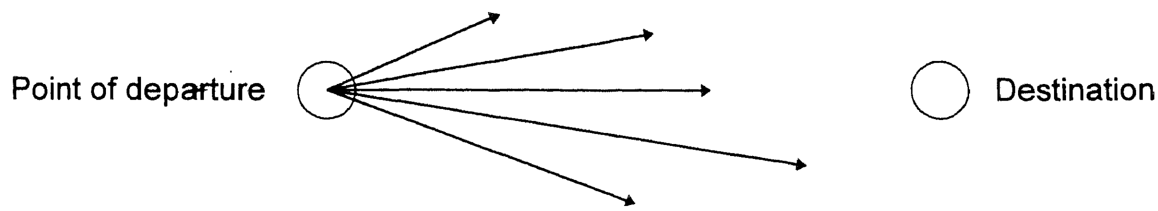


Figure 1. Darwinian theory of evolutionary process.

Darwin's evolutionary view had its first impacts in theology, religion and philosophy and subsequently in many more areas of intellectual activity. Ideas of evolution were also applied to design, architectural theory, and to the study of material culture in archeology and ethnology. The impact of Darwinian theory on design was the suggestion of a gradual process of evolution rather than the free play of imagination. The evolutionary view did not give the same weight to originality, creativity and to novelty as it did to inheritance and experimentation.

An example of the analogy between Darwin's concept of organic evolution and evolution of artifacts is seen in the works of some architects. In the design of new tools or buildings, Viollet-le-Duc equated heredity with coping. While coping he made some variations simply accidentally, at random. He believed that designs with slight variations confer a particular advantage and constitute an improvement over the previous ones (Figure 2).

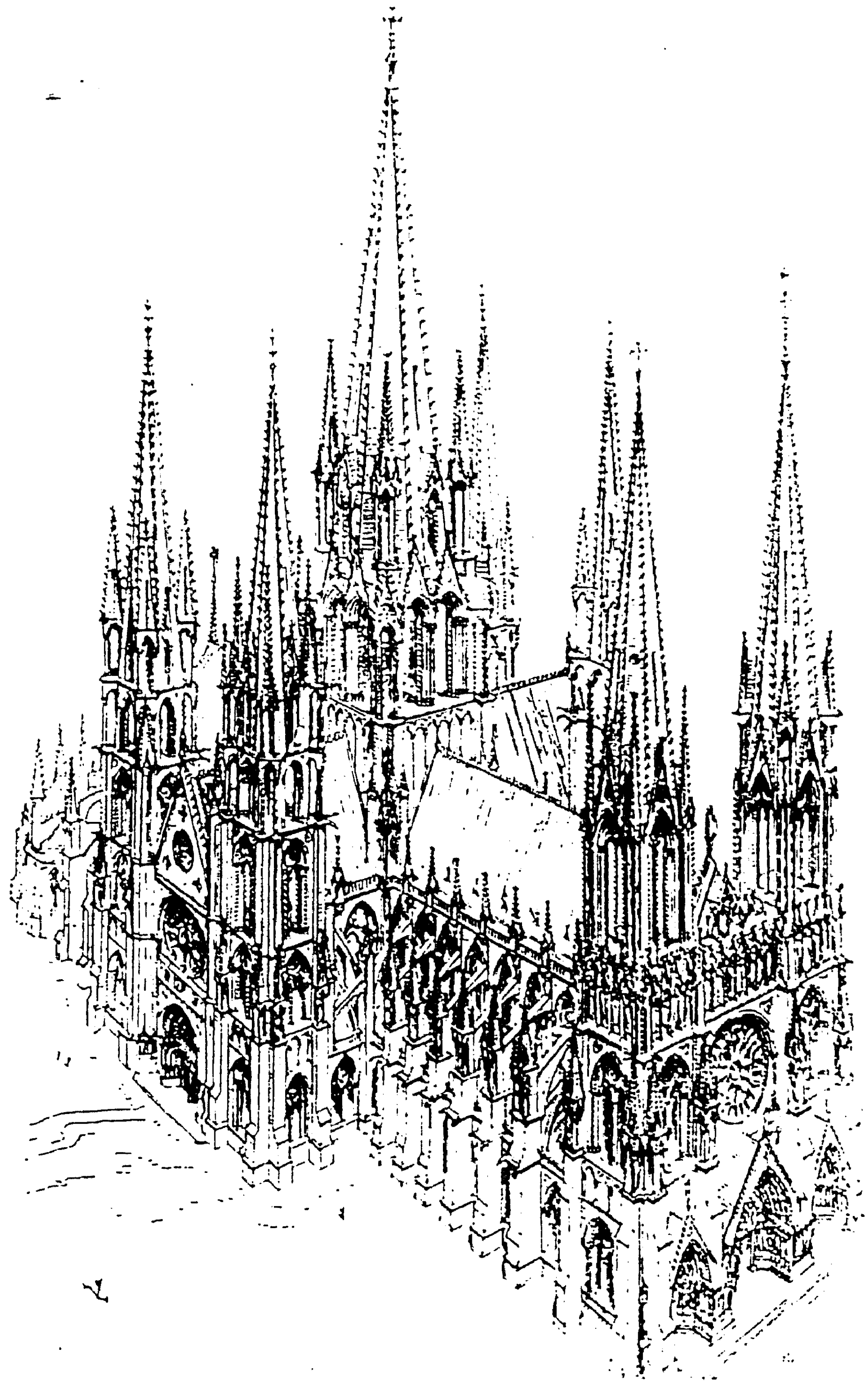


Figure 2. Viollet-le-Duc's ideal or theoretical model of the Gothic cathedral [Steadman, 1979, p. 71]

Le Corbusier in "Vers Une Architecture" illustrated the evolution of car designs (Figure 3) and temple designs. He developed his philosophy of Purism based on the ideas about the evolution in design [Steadman, 1979]. Given a particular functional requirement, and utilized a criterion of selection according to economy, Le Corbusier envisioned some standard universal type that fulfilled that function.

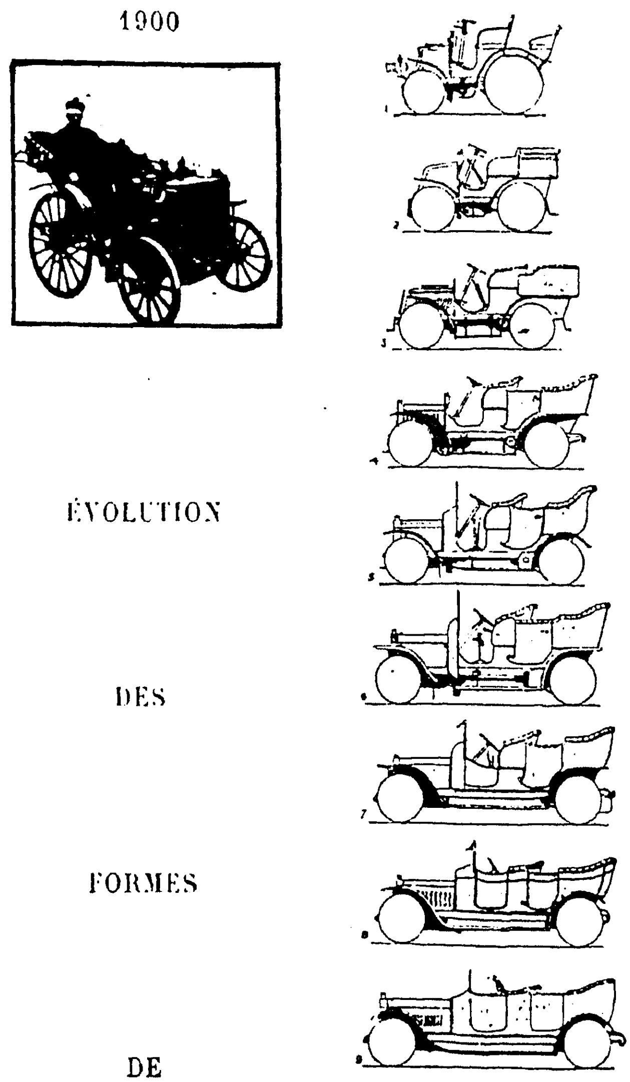


Figure 3. Evolution of motor cars [Steadman, 1979, p. 142].

Darwinian theory and its applications in the evolution of artifacts, conceived progress as a perfectly random and spontaneous process. Many of the Darwin's critics come to this argument - rendering the whole evolutionary process as purposeless and meaningless. In his "Internal Factors of Evolution", L. L. Whyte criticized Darwin's theory, and argued that evolution is not a transformation through gradual stages, but is achieved by radical and sudden changes (Figure 4). R. B. Goldschmidt in his theory of "hopeful monsters" argued that some big, fatal occasional mutations, few of which survive, characterize evolution [qt. in Steadman, p.256]. Teilhard de Chardin viewed the overall process of human evolution as a pluralistic process that may be compared to moving along the meridians of a globe, starting from one pole (the common beginning) and leading towards the other pole (the common telos, or Point Omega) [Teilhard, 1972].

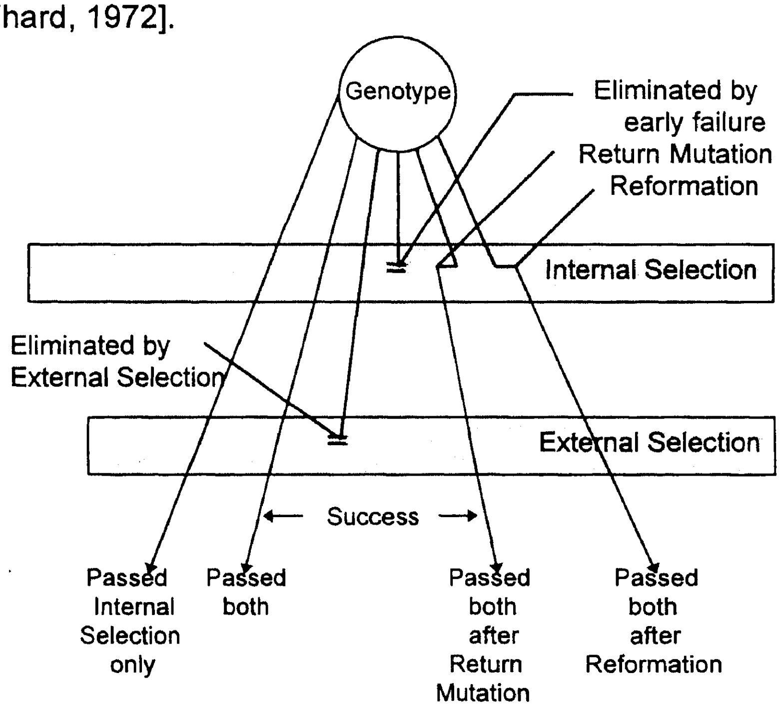


Figure 4. Whyte's theory of evolution [1965, p. 70].

As presented above, the history of evolutionary theory presented a number of theories on evolutionary progress. However, discussions on this subject still do not come to a consensus. The theory of evolution still remains one of the debates within biology as well as in design philosophy.

With the study of biological evolutionary theories and their analogies with design, the author has come to a belief that evolution is a process of continuous change from a lower level or simpler condition to a higher and better state. Unlike a purposeless and multi-directional Darwinian attitude, but similar to Teilhard's theory of evolution, this thesis visualizes the evolutionary process as a process of moving from one point (lower level) to a particular result or end (higher level) (Figure 5).

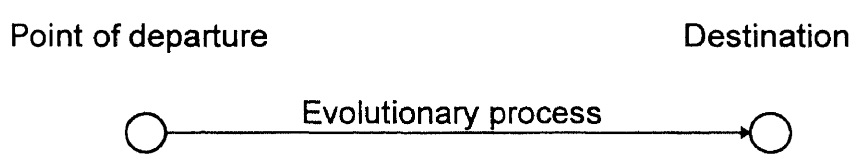


Figure 5. The theory of evolutionary process.

The underlying philosophy of evolution is the commitment to adjust all aspects of the human system in a way that would be desired by most people. Evolution is more than a change - transformation to a condition. It is more than an array of interacting processes. Evolution is the higher order of change. Evolutionary process carries into being this new and higher order of change [Jantsch, 1975].

The theory of evolution offers three concepts; *lower and higher level, and process*. Lower level is the state with which people are not satisfied. A lower level in design is the *point of departure* of an evolutionary attempt. Actions are felt to be possible and necessary for changing the lower level. Higher level is the *destination*. At this higher level, things are assumed to be better - more desired - than they once were. An *evolutionary process* is an artificial or voluntary progressively continuing operation that consists of a series of controlled actions or movements systematically progressing to a higher level.

The essence of this evolutionary view is that progression implies a destination and moves towards it. With a commitment to improve design as a whole, evolutionary process navigates itself towards the achievement of a "better" or an "ideal" design. Actions and movements are taken to arrive at that destination. The questions become: *What is the destination? What is a "better" or an "ideal" design?*

It is not the intention of this study to define the identity and merit of a better design or describe what is a "bad" or "good" design. The reason for this is that, values in design are in constant change. What is described to be a "bad" or "good" design differs with a change in time, location, personal values and other variables. As the evolutionary process unfolds, the point of departure (undesired state of design) and the destination (desired state of design) change in four dimensional space and time. This means that in the process of progression, humans tend to conceive of other ideas or philosophies, and slide gradually towards other destinations. Even though humans have basic tendencies to move towards certain configurations, they do not sometimes end up in those configurations, but somewhere else. Destinations of evolutionary design studies change as the process unfolds. (Figure 6). Consequently, the configuration of the process designed in order to arrive at the initial destination becomes irrelevant for that intention.

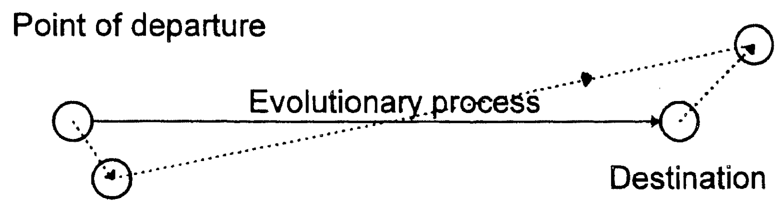


Figure 6. Changing values in the evolutionary process.

CHAPTER 3

IDENTIFICATION OF LOWER AND HIGHER LEVELS OF DESIGN

Design studies aim to improve design, to make things better than before. However, a commitment is not sufficient for the achievement of that objective. Improvement requires an awareness of the weaknesses and complaints, as well as the satisfactions and potentials of design. A progression of design requires the design of a process that would eliminate the weaknesses and increase the potentials.

With these requirements in mind, two objectives of an evolutionary approach should be:

1. identification of the lower level of design
2. prediction of the highest, ultimate state of design

This chapter studies some of the current responses to design which were brought by those involved in design as well as those influenced by it. A study of the responses to design, in return helps specify and understand the reasons for satisfaction and dissatisfaction with the current state of design. The second objective of this chapter is to identify an "ideal" design. To achieve this, the author envisions a design system that eliminates the weaknesses of design. Such a system not only eliminates one or several weaknesses or increases one or more potentials of design, but predicts all the major social and physical arrangements that would be necessary and desirable in the future.

3.1 Design and Its Past Goals

> "If we are to design the future and improve the quality of life, we must determine how the state of our affairs differs from that of earlier societies."
>
> [Ackoff, 1974, p.4]

In this section, the main objective is to discover and explain the goals of previous design studies. A discussion of the objectives and means defined by these studies provides a general understanding of the "ideals" of the past. In the following sections, the author shows that the "ideals" of previous design studies were set out to be achieved via describing and prescribing design. Almost all of the previous design studies developed *descriptions and prescriptions of design*. *Descriptions of design* aims to develop an awareness of the facts of design and the capabilities of the designer. P*rescriptions for design* are logically rigorous procedures for achieving optimal ends.

3.1.1 Design Descriptions

Deterministic attitudes towards the understanding of design provided the intellectual foundation of previous design studies. These studies favored the idea that everything about design can be determined. They wanted to find and learn the facts about design. Almost all of the investments were directed towards the *externalization of design* - the understanding and explanation of design to others.

Many of the approaches to externalize design conceptualized design as a glass-box. Designers believed that one can examine design without any obstacle. They favored the idea that design can be pinned out like a frog on a dissection table and that all the facts about how one designs could be learned from the dissection of design.

With the externalization of design, design researchers attempted to bring the design process into the open, so that people could see what is going on and contribute to the information and insights that are outside the designer's knowledge and experience [Jones, 1992]. However, descriptions and definitions of design were not only used to indulge the investigator's or others' curiosity. An understanding and a description of design were believed to provide a conceptual framework and an operation notation within which designers might work [Archer, 1969]. In many cases, an understanding of design contributed to a conception of what it should be. This understanding was consistent with the belief that, the better one understands design, the better one can produce more desired designs and practice a more "elegant" design process.

3.1.2 Design Prescriptions

With the emergence of human complaints about the nature of design, designers dedicated themselves to the exploration of an "ideal" design. Designers believed that they would reach an "ideal" design or a "better" design by developing the "one best way" of designing. Development of the "one best way" of designing was believed to achieve the ideals of design. Gradually, these same people came to believe that it was impossible to develop "one best way" of designing. Emphasis shifted to the development of *prescriptions* that would make design better than before.

Prescriptions for design were developed with the intention to improve design in practice and theory. However, most of these studies were restricted with a concern only over the development of powerful tools and methods. Most of the researchers prescribed either *design methods* or *design tools* for the improvement of design. Design methods are techniques for designing. *Design tools* are instruments with which designers could be equipped.

3.2 Current State of Design

The central objective of past was to improve design by bringing ideas on how to practice a design process and what tools to utilize. Some of these studies were rather successful in finding new ways of designing or in inventing new tools; some were not. Whether they succeeded or not, they played an important role in shaping the current state of design techniques and tools.

If current state of design is a part of the previous evolutionary design process, the question to be answered is: *What were the impacts of previous evolutionary design studies on the current state of design? What will be the impacts of the current state of design on future designs?*

3.2.1 Descriptions of Design

Descriptions or definitions of design are developed via systematic design inquiries and rational design studies. Objective and unbiased information about the nature of design are gained from the actual observation of design. An intellectual examination of internal sources of knowledge is gained from rational design studies. The two dominant approaches to rational design studies are *analytical and systems thinking.*

Ackoff describes an analytical thinking and says:

"Analysis consists first of taking apart something to be explained - disassembling it, if possible, down to the independent and indivisible parts of which it is composed; secondly, of explaining the behavior of these parts; and, finally, of aggregating these partial explanations into an explanation of the whole" [Ackoff, 1975, p.2].

An analytical approach to design disassembles design into independent, dependent and indivisible parts of which it is composed. It explains design by:

a) dividing it into fragments,
b) explaining the fragments,
c) combining the explanations of fragments into an explanation of the whole.

The systems approach criticizes the analytical approach. It opposes understanding design via analysis. It, instead, conceives design as a system and understands it as part of a larger system.

In his publication "The Systems Approach", C. West Churchman describes a systems approach as being simply "a way of thinking about total systems and their components" [1968, p.11]. A systems approach concerns itself with large systems and tries to describe them in a way that would not occur to most people who tend to look at the world in one way, namely, the way that is most familiar to them. A radical approach to thinking tries to disturb the typical mental process by simply questioning the overall objective of a system [Churchman, 1968].

A systems approach to design conceives of design as a system which is made up of sets of components that work together for the overall objective of the whole. It first thinks about its function, and not the list of the items that make up its structure. A radical approach to design thinking describes design in terms of the relationships between diverse components that serve a complex unity.

Both analytical and systems approaches describe and explain design via *design models and theories.* Design models, or so called theories, form conceptions, judgments and presuppositions by speculation and deduction, or by abstraction and generalization from facts.

Some people argue that design models somehow operate in a way that is analogous to the way in which design behaves. However, Bruce Archer [1969] argues that no analogue model behaves in every way like the actual design behaves. In the development of models, no analysis or no systems approach may depict the actual design. Models describe what was perceived to be design, the image of design ideas. For that reason, some researchers, like Archer, conceive of design models as prototypes that might help visualize design in simplified ways.

Design theories and models, resulting from analytical and systems approaches, bring in new descriptions of design in different formats. In some cases, a description brings in a statement or a set of statements. Sometimes, it explains design via mathematical symbols, and nearly always with a diagram representing parts of the design problem and the relationships between them.

Verbal descriptions of design bring in definitions that either compare or liken design to other activities. They explain design in terms of the explanations known for other activities. In some cases, design is likened to a decision making activity [Asimow, 1962], to a puzzle making activity [Alexander, 1964], to a goal-directed problem solving activity [Archer, 1969].

Another way of describing design is through mathematical descriptions. Mathematical descriptions of design give a formula to the logic of design. They utilize mathematical notations similar to the basis of operations research in an attempt to lay ground to a science of design which is compatible with operations research and management science [Bazjanac, 1974]. An example of a mathematical formulation of design is presented below.

O(y) = f P(x) (where f signifies some function of f

O signifies an objective or a goal

P signifies a property or a condition

O(y) signifies a particular degree of fulfillment of an objective

P(x) signifies a particular state of a property

[Archer, 1969].

Early graphical models of design depicted design as a sequence of well-defined activities. The best known graphical models are developed by Alexander [1964], Asimow [1962], Archer [1969] and Jones [1970]. Asimow's model [1962] consisted of three phases: analysis, synthesis, and evaluation and decision. (Figure 7). Archer [1963], as quoted in Broadbent [1988], plotted a reiterating sequence of analysis, synthesis and evaluation in spiral form (Figure 8).

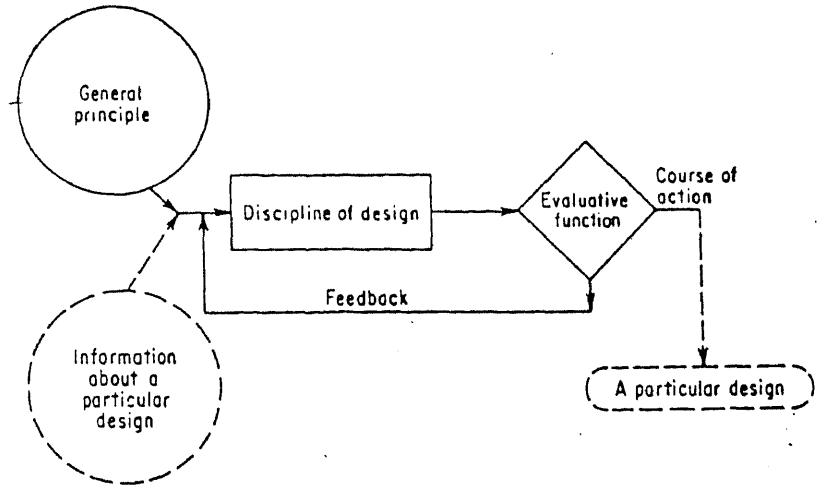


Figure 7. Philosophy of design [Asimow, 1962, p.5]

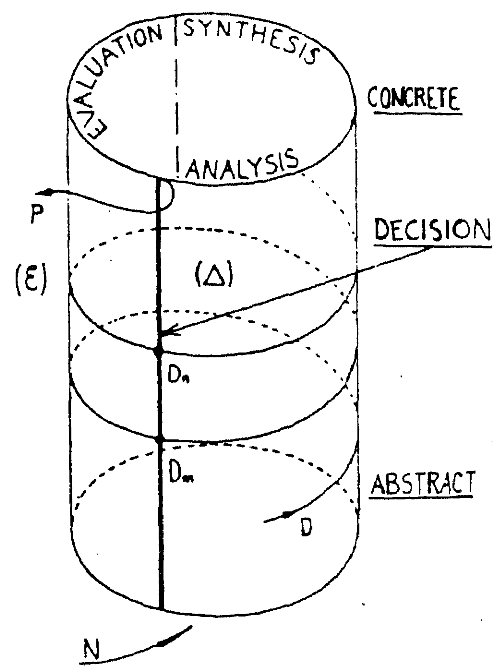


Figure 8. A reiterating sequence of design process in spiral form [Archer, qt. in Broadbent, 1988, p. 258].

Early models have one characteristic in common: they all viewed the design process as a step-by-step process [Bazjanac, 1974]. For the modeling of this step-by-step process, researchers decomposed design into a number of phases. Cause and effect relationships were utilized in establishing a hierarchy among these phases. The result was a tree diagram of design (Figure 9).

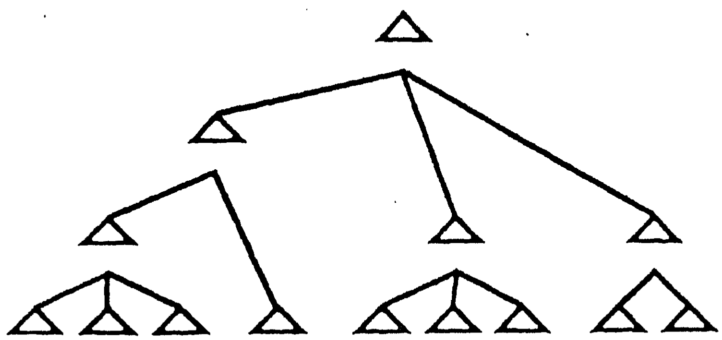


Figure 9. A tree diagram [Alexander, 1964, p.82]

Other models of design viewed the design process as composed of nonlinear cycles. In these models, a network relationship established an argumentative process in design [Bazjanac, 1974]. The best known models of this type is Rittel's model [1967]. As Bazjanac describes, Rittel's model views the whole design process as sequential problem-solving in which cycles are not linear; they form networks.

3.2.2 Design Methods

In the development of prescriptions, a range of techniques became available to the designer. From ergonomics, operational research, systems analysis, information theory and certain other disciplines, a range of techniques originated and developed. Because of the existence of a vast variety of techniques, some designers felt compelled to use them.

The development of design methods was based on a growing understanding of design and the techniques available to the designer. Due to the limits of the understanding of design, designers divided methods into either *black box or glass-box design methods* [Jones, 1992]. A conception of design as a black box saw it as a mysterious process (Figure 10). This led to the development of black-box design methods.

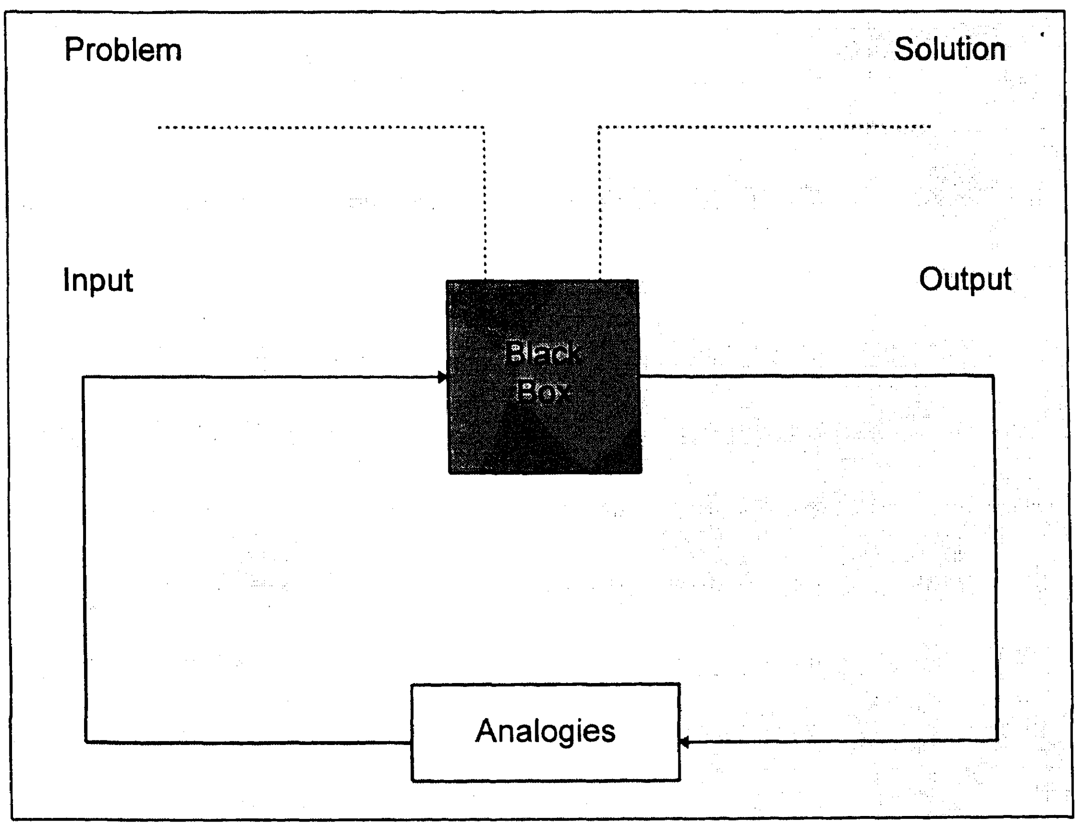


Figure 10. Black-box understanding of design [Jones, 1992, p. 48]

When the design process is assumed to be explicable, rather than mystical, designers turned to rational or systematic design methods. In the development of systematic design methods, designers believed that the design process operates as information fed into it and following a known sequence of steps that can cycle until it results in an optimum solution (Figure 11).

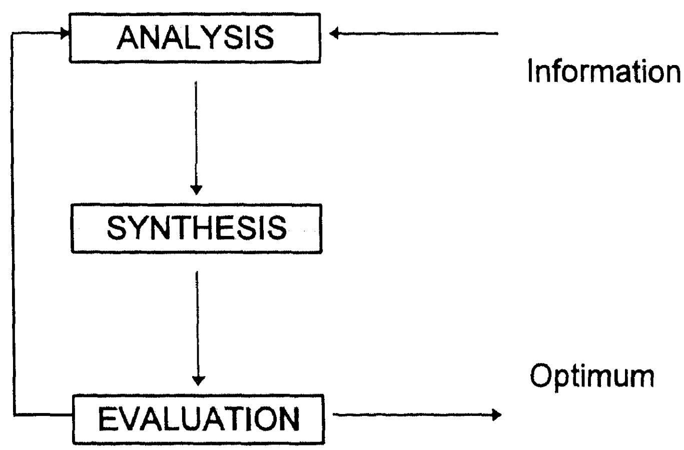


Figure 11. Glass-box understanding of design [Jones, 1992]

With a glass-box approach, researchers believed that they could offer a new and an "elegant" way to change design. They tried to develop methods that would be elegant in a technological sense - simpler, efficient and cheaper [Broadbent, 1988]. An "elegant" design process was assumed to be more linear and less circular [Jones, 1992]. Less circularity implied less gradually developing decisions and less revision of the decisions. More linearity implied a quick arrival at a solution by a single run through the linear sequence of analysis, synthesis and evaluation.

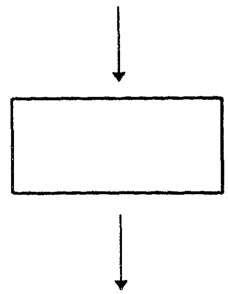
3.2.3 Tools for Designers

Many design studies gave a great amount of thought to develop tools. They tried to develop tools that the designer might use. Design tools were machines designed to act as powerful aids. They were believed to improve design as a whole.

In the history of design, design tools have been developed as extensions of, or substitutes for, various organs of the designer's physical body [Steadman, 1979]. Beginning with the First Industrial Revolution, tools or machines or other implements replaced the muscle power of the designer. Machines undertook the task of generating and remembering symbols, or so called design data. These tools mechanized *design communication*, the transmission of design data. They were used to "bookkeep designing": keep records of spatial position, dimension and shape [Porter qt. in Schon and Bucciarelli, 1988]. For example, drafting tools or modeling tools were equipment utilized to generate and record properties of designed artifacts.

The technology of 1940s produced electronic digital computers. This new technology was based on the mechanical computer idea of Babbage in 1836. One of the simplest functional diagram of a computer is depicted by William J. Mitchell and Malcolm McCullough [1991] as being a device for processing available information input to produce the required information output (Figure 12).

Available Information



Required Information

Figure 12. Functional diagram of a computer [Mitchell and McCullough, 1991]

Computers replaced human mind in doing rational tasks. These machines had the capability to manipulate data in terms of logical, linear processes. They could organize data into information. Then, they could organize the information into instructions [Ackoff, 1974].

Designers, like other people, tend to utilize information-producing (data-processing) and instruction-producing (decision-making) capabilities of computers. In the early 1960s, they tried to develop computer-aided design with the intention of defining a method of "systematic design". Currently, designers are giving much thought to find ways to automate or computerize the design process. The prevailing intention is to automate the whole design process, not just discrete logical steps.

Today, a variety of the design tools are dependent on computers. Automated tools are utilized at various stages of design, starting from the conceptual design processes through to the construction processes. Computers are used as a tool box. They are given capabilities for doing certain operations.

Currently, different benefits are being achieved in design practice, education and research through different kinds and levels of investments in computer technology. Some of the dominant utilization of computers in design are described below:

- Computers are used to do routine layout tasks. Cost and engineering calculations performed by automated tools reduce the cost and time to complete a project.
- Computer technology automate the retrieval of construction data, standard details, building code requirements and other information needed in design. Computerized systems store, update, search and retrieve knowledge in specialized domains.
- Computers are equipped with some capacity to sense, model, plan and act autonomously to achieve work objectives. With these qualifications, robots, are programmed to perform sequences of operations in various fields, such as in industrial construction.
- Computers record information about the existing world and allow fragmentation, combination, distortion, duplication, tweening of recorded information in design. For example, digital image scanning processes record images from the physical (built and natural) context of a site, from a history or from previous work produced by the designer [Goldman and Zdepski, 1990]. Image sampling permits the designer to collage visual information into new design proposals (Figure 13).

Figure 13. Matting a synthesized image into a captured image [Mitchell and McCullough, p.229]

- Computers automate documentation. Computer drafting systems allow greater efficiency in the production of working drawings. Word processors assist in the production of specifications and other text documents. Digital drawings reduce the cost and time of recording information, moving it, and translating it into different formats as required by participants in the project. These techniques allow a faster and cheaper organized cross-communication among participants.
- Computer-aided-design and computer-aided-manufacturing achieve benefits in the standardization and mass production of components. Computer controlled tools are used to produce complex and multiple copies of objects (ARU, 1971; ARC, 1975).

Computers are used to predict cost and performance of design proposals. In architecture, dynamic seismic analysis of building performance provides useful information about how a proposal may behave. Currently, performance evaluation tools are developed to follow such attributes:

a) spatial characteristics,

b) lighting,

c) acoustics,

d) fire safety,

e) internal climate,

f) durability and maintenance,

g) user's health and safety [Wiezel and Becker, 1992].

Examples of evaluation programs are:

ARCH: FIRE SAFETY program [Ozel, 1985] develop to evaluate the fire safety requirements of buildings. ENERGY [Kalay and Shaviv, 1992], CALPAS3 [Berkeley Solar Group, 1984], ENERGY EXPERT [Jog, 1992] programs analyze the approximate energy performance of a building. COSMOS is a multicriteria evaluation program which simultaneously calculates and evaluates building cost, energy consumption, acoustics, lighting and construction of a design (Figure 14).

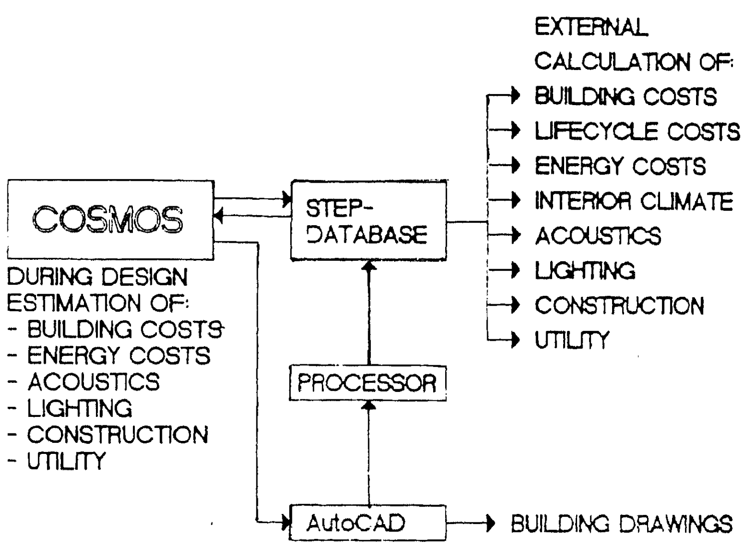


Figure 14. Diagram of the design and evaluation system (COSMOS) [Hacfoort and Veldhuisen, 1992, p. 203]

Realistic visual representations of design artifacts allow the designer to infer semantic information directly from the image, as one would from a physical scale model or from the real artifact. Faster simulation of design proposals allow experimentation with a large number of alternatives. In design education, design students are learning and retaining knowledge from experimentation with large number of alternatives [qt. in Carrara et al., 1992].

- Current CAD tools are facilitating the representation, visualization, simulation of information, design products, context and people. Computer graphics simulate what we already know about design decisions by two-dimensional, three-dimensional drawings, and renderings. The new representation techniques like 3D modeling, animation and multimedia, multiscopic views, and virtual reality depict four-dimensional phenomena - the experience of volumetric places and temporal occasions - and make possible the experiential evaluation of design decisions. For example, in architectural design, viewing a three dimensional computer model from many vantage points and through animation sequence, presents buildings and their surrounding environments as a sequence of spaces and events, rather than as static objects or graphic abstractions [Goldman, Zdepski, 1987]. As Goldman and Zdepski states, the understanding of the spatial and formal properties of building design studies via three dimensional modeling diminishes the fragmentation in design thinking as one moves from site, to building, to detail. This visualization, simulation technique lessens the dominance of plan as the form giver [1987].

Virtual reality (VR) techniques enhance the design process, design exploration, as well as analysis and discovery in design practice [Schmitt, 1993]. Gerhard N. Schmitt describes the performance of advanced CAD applications and VR systems in (Figure 15). Left side of the figure show that advanced CAD applications enables the study of specific aspects of a design by having separate programs performing calculations on certain properties. Right side of the figure shows that VR environment makes design analysis an integral part of the design. It puts the designer (architect) inside the design, and the design becomes influenced from the interaction with the designer (architect).

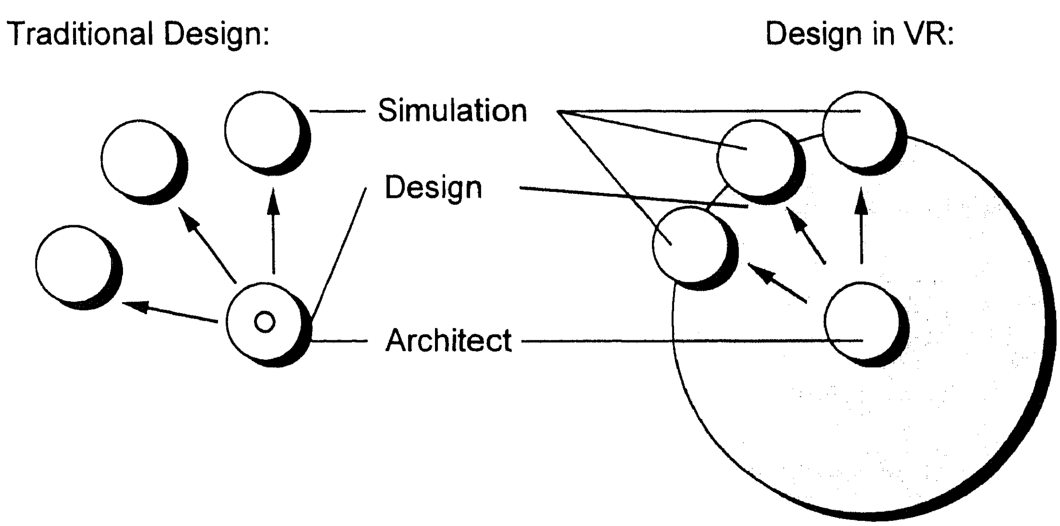


Figure 15. Traditional design versus design in VR [Schmitt, 1993, p.86].

Constraint-based paradigms are utilized to represent physical and geometric properties of individual components that make up an artifact in a single, shared computer based model [Baecker et., 1991]. They depict the information pertaining to a particular entity or group of entities, and allow the interactive modeling of conceptual elements within, and constraint to, a design space, including the realistic interaction between the entities themselves [Tobin, 1991]. In the design of an building in a site, a constraint-based model impose the zoning regulation to a design. Figure 16 shows a constraint-based design space which contains specific information, or design knowledge, about the allowable design volume.

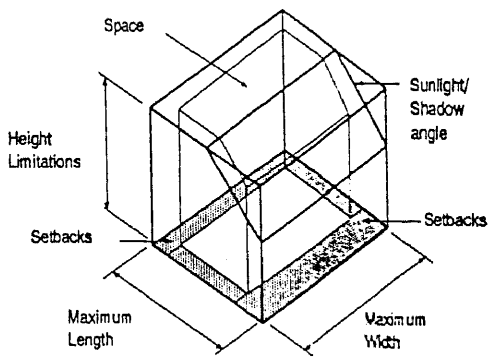


Figure 16. Design knowledge of a space created by a constraint-based modeling [Tobin, 1991, p. 195].

- Computers are being used to generate a large number of obvious, logically predictable design solutions. Generative systems derive solutions by adopting similar design solutions or by finding the most appropriate answer to predefined objectives and constraints. Generative systems carry out sequence of predetermined instructions corresponding to the given data in order to obtain specific results. Generative CAD systems interpret design goals and produce geometric descriptions. They generate solutions by requesting certain information from the designer and by interacting with the user textually.

Integrated CAD tools allow the interaction of a set of operators (agents), each accommodating and integrating many perspectives within design and sharing information in a collaborative organization (Figure 17). Some examples of the generative CAD systems are PREDIKT [Oxman, 1992], and SABA [Liggett, 1992].

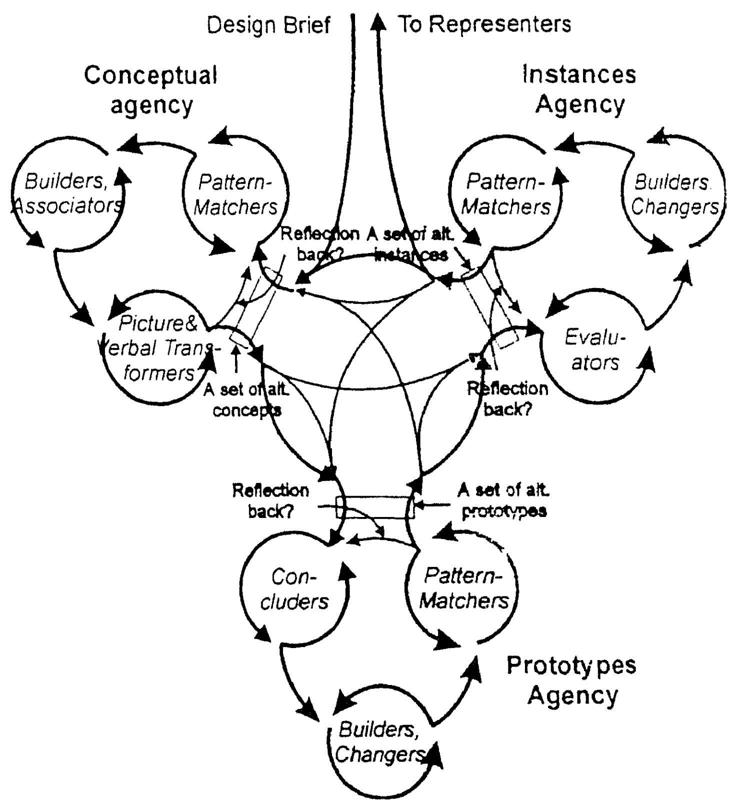


Figure 17. A network of design agents [Petrovic, I. K., 1995, p. 178].

Another way of sharing design ideas is facilitated on information superhighways. Some examples of the interactions among design participants in real time are seen in the works of Frazer at the Architectural Association and the University of Belfast [qt. in Glanville, 1995], New Jersey Institute of Technology and Massachusetts Institute of Technology.

- New techniques and tools used in the accumulation, visualization and simulation of design information seems to change the way design professionals communicate. For example, component-based paradigms enable the design consultants to share, manipulate and communicate design information in a single form of representation. A component-based paradigm, described by Harfmann and Chen [1990], represents components of building systems and the relations with each other within a database and a single model. The goal of this paradigm is to facilitate the complete understanding and integration of the complex inter-relationships of building systems and components with a single model and a multi perspective component representation. The implementation of this approach is anticipated to result in fewer communication problems that currently plague the fragmented process of practicing in the professions of architecture and engineering [Harfmann and Chen, 1990].

The current trend in multimedia computing is toward incorporating full-motion digital video and audio into many types of application. In design practice, the computer with multimedia capabilities and cross-media applications (film, video, television, and scientific visualization) integrate the design proposals with the existing physical information (light, topography, climate), sound (music, speech, background sounds) [Goldman and Hoon, 1994] and motion. Multimedia systems with audio interface free the act of recording data from the necessity of using the hand and the eye. The medium of communication facilitates (recorded) human speech, not just icons representing human communication [Buford, 1994].

- Progress in hardware and software networking technology has made possible the world-wide integration of computing and storage resources [Durst, 1993]. A computer system vastly speeds up the process of reaching a needed data. Emerging global network contains huge amounts of information in various formats (e.g. texts, sound, two-dimensional images and drawings, three-dimensional models, four-dimensional kinematic models and various multimedia combinations of them). A network of references makes possible the integration, interaction and synchronization of data in any format and from any source.

Certain characteristics of our current use of computation are classified by Radford and Stevens [1987]. Due to this classification, CAD tools fall into one of the three categories; *simulation tool, generation tool and optimization tool.*

1. Computers when utilized to simulate - give a description of the relevant characteristics of a design proposal - are called simulation tools. Computerized simulation tools illustrate design decisions that are already made. They predict and describe the visual, functional, structural, environmental system performances of a design proposal in some performance area. Simulation tools define the consequences of a design decision. Two and three-dimensional drawings produced via computers model the artifact or the scene they depict. Textured and colored renderings and walk-throughs describe the physical appearance of a design artifact. Photorealistic images facilitate the visualizing of design consequences in respect to the relation with its performance area. Virtually constructed environments enable the post-human existence and

existential experience of an environment or an object. Likewise, investigations of structural, economic, environmental performance of a designed artifact illustrate the quantitative aspects of design.

2. *Generative tools* generate a design solution according to prescribed rules. By questioning and suggesting, generative tools enable exploration in design. Computers when utilized an ordered set of design rules, help explore solutions to a given problem. A computer program for the design of fixed external sun shades developed by Edna Shaviv [1992] is an example of a generative model.
3. *Optimization CAD tools* seek to answer the designer's fundamental question of what is the "best" solution [Radford and Stevens, 1987]. By simulating the performance of decisions in a predefined criterion, an optimization tool identifies the solution that achieves the best performance. Well-established algorithms provide the means for finding an optimal solution to a design problem.

3.3. Discussion of the Current State of Design

The changing ideas of what design is have affected public consciousness, perception of what designers are, and of what investigations should be made for improving design.

Currently, we are faced with a number of descriptions and prescriptions produced by black or glass-boxers. The literature on design presents a diversity and a contradiction in the externalization of design. This encourages a confused understanding of design. In these circumstances, one's affinity with any of the design delineation or the instructions for design is a consummation of a personal judgment. Nourished with a vast variety of descriptions and prescriptions of design, a person chooses the one that is closest to that person's view of the world. In some cases, people ignore all the available theories or instructions and explore their own understanding of design. It seems evident that these circumstances in design lead to acrimony and fragmentation of the design community into schools and sects, each incorporating a different vision of the meaning of design [Buchanan and Margolin, 1995]. Rather than bringing a consensus among designers, discoveries of design lack a conceptual framework to be shared by the community of designers (architects, industrial designers, etc.).

Buchanan and Margolin point out the absence of a conceptual framework in design and state that:

> ". . . design has been considered too narrowly and the central role it plays in social life, both as an activity in which everyone engages and as one that results in products that are inextricably intertwined with human action, has been neglected" [Buchanan and Margolin, 1995, p. xvii].

Today, designers are faced with ongoing discovery of prescriptions that advocate how design should be done in particular circumstances. Design methods in the form of "if-such-and-then" are offering designers ways of designing certain elements and objects. However, contrary to the expectations, application of design methods results in abstract theories produced by academic studies of methods (methodologies). When design methods are used in design practice, they fix the aims and methods used to produce a design product. The resultant of these applications is the establishment of a rigidity in designing [Jones, 1992].

Today, designers are using manual or computerized design tools for improving design productivity and quality. Computerized tools are being utilized to automate the overall design process. For improving design automation, researchers are reconsidering logic and the methodology of design. They are analyzing design - disassembling design into independent and indivisible tasks - and considering the availability of computer tools to perform these tasks [Mitchell and McCullough, 1991].

Appropriate use of design tools and design methods are removing some constraints on the capacities of designers to pursue ideas. Significant achievements are seen in automating partial or specific design processes. However, analysis of the design process and the search for possible applications of computer technology do not guarantee a better result or a design system.

3.4 The Role of Ideals

In this section, the author conceives of an "ideal" design system that would eliminate the weaknesses and complaints and increase the level of satisfaction with design. This section makes a survey of idealization thought in design and articulates an ideal in thought.

A proposal for eliminating one or several weaknesses and for increasing one or more potentials of design is not sufficient for the achievement of a perfect configuration of design. To achieve an ultimate state of design, such a proposal should describe all the major social and physical arrangements that are necessary and desirable. However, many desired characteristics that the future design ought to have may not be known at the current time. For that reason, an identification of a higher or a better level of design is only a prediction of design consequences that would be satisfactory in the future.

In the prediction and visualization of an "ideal" design, the author recognizes the fact that humans have a diversity of legitimate values and this might lead to an opposition of principles or values. Agreement on an "ideal" design therefore should be achieved with the establishment of a non-private standard of judgment. In this spirit, the author aims to elucidate the characteristics of an "ideal" design and asks four important questions:

- *What is an ideal?*
- *What is an "ideal" design?*
- *Why do we need to idealize design?*
- *How it is related to the evolution of design?*

3.4.1 What is an Ideal?

An ideal is a perfect, absolute, consummate, best, most faultless, flawless, pure, unblemished, choice, paragon or quintessence [Nadler, 1967]. An ideal is something in its highest state of perfection.

An ideal can be static and absolute. It does not need to move from one place to another. An ideal can be absolute in the sense it is a depiction of the creator's current ultimate values. However, it has a relative conceptualization due to the fact that it is a representation of the creator's currently imperfect information about, and knowledge and understanding of the highest state. In these circumstances, an ideal is called a "relative absolute" [Ackoff, 1974].

There are some restrictions for achieving an "ideal", but realization or attainment of an "ideal" is desirable, if not possible. The achievement of an "ideal" begins with a clear vision and understanding of what it is or what it should be. It continues with the notion of an unfettered state in which there are unlimited resources and no restrictions on thought. With a clear vision in an unfettered state, an "ideal" satisfies the requirements at all levels.

3.4.2 What is an Ideal Design?

The ultimate objective of a design endeavor is to achieve the "ideal" design; the best, perfect and faultless state of design. However, investments are not always directed towards the achievement of this ultimate objective. Rather, they are organized to conquer current problems and restrictions. The reason for this is the disbelief in the possibility of achieving the highest level of design with the resources and the knowledge available now.

We might not have the necessary resources and knowledge, but we should still ask: *What are the characteristics of an ideal design?*

The author's conception of an "ideal design" is defined by the following properties:

The concept of an "ideal design" implies a perfection in the overall performance of a design system. In this system, all parts contribute to the purpose of the whole and no part may be removed without some damage to the whole. The qualities of wholeness, of integrity, and of unity are the basis for a perfect design system.

An ideal design is a perfect coordination and integration of those parts of the design system. It is a perfect intercourse among *design practice, education and research.*

Humans always have changing appetites. They seek new beauties. Vernon as quoted in Broadbent [1988] presents his conception of man in relation to his environment and says:

> "I believe that the human being cannot long endure a completely homogenous situation no matter how good or how desirable it is. What is homogenous soon becomes boring and undesirable . . . No matter how positive a thing may be, it loses value under unvarying use. Man's appetites soon become jaded, so that he ever seeks new gratifications or, failing this, finds increasing complaint with this status quo."
>
> [qt. in Broadbent, 1988, p.141]

In this context, humans will not even be satisfied with an ultimate beauty. They will have changing desires and conceptions of what it should be. Initiation of new desires will require some inducements. The question is: *What sort of inducement is needed?*

The author envisions a perfect design product as being a sensory stimulus. It learns effectively from experience and adapts itself to environmental changes. The consequences of an unblemished artifact satisfy all the individuals that exist in the performance area of that artifact. An ideal artifact stimulates man's jaded appetites and offers a relief from boredom. By sensing man's relatively changing appetites, an ideal artifact transforms itself into a state that would achieve new gratifications.

A design product has no limitations for what to achieve. This does not mean that it has no "predefined" functions. Considering the human's current needs or appetites, a design product may achieve short- or long-term goals which define the desired state for a certain time, space or group (or individual). However, a perfection in design does not require a product specifically designed for achieving a specific function or goal. A perfect artifact attains the short- and long-terms goals as well as the emerging and changing ones.

An "ideal design product" may not be discovered right away, but once it is designed and utilized in an unfettered environment, "designing" of that product is completely resolved. No further activity is necessary or desirable for "redesigning" it. Redesigning of a design product is not required, but it may require some adjustments and transformations in respect to the changes observed in human appetites.

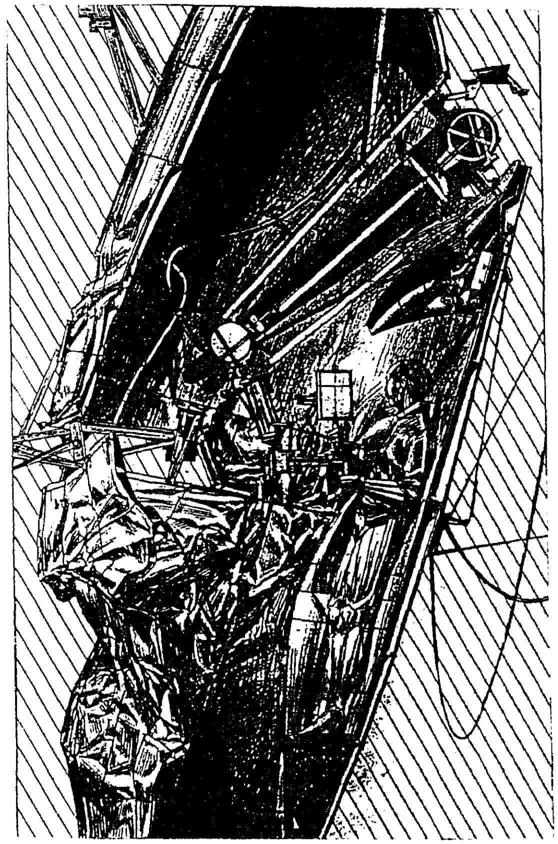


Figure 18. Freespace interior with self referential instruments [Woods, 1992].

A “free space” concept in architecture is consistent with the conception of an ideal design product as a “sensory stimulus”. “Free space” or “free-zone” concepts introduce the possibility of a free, nondeterministic and dynamic architectural system that is compatible with uncertainty, ambiguity and unpredictability in the complex heterarchies within the natural and human worlds. Lebbeus Woods [1992] exercises the “free space” theory by conceptualizing a structure which changes continually according to changing needs and conditions (Figure 18). However, one would recognize that the exercises on “free space” are incomplete and imperfect because there are many questions to which the designers do not have ideal answers.

An "ideal design process" is the integration of designing and implementation. It balances the rational, sensory and emotional expectations of users and society with a design product. In this process, design participants are conscious of all those expectations. They have a clear understanding of the requirements. An interactive and responsive design process recognizes the fluctuations in human needs and appetites, and allows the modification of the parts that are going to be produced or of those that were produced.

For developing an Ideal Design of Effective And Logical Systems (IDEALS), Nadler [1967] establishes a detailed checklist and requires a strict adherence to it. He believes that affiliation with fundamental principles and axioms makes design processes more creative. Nadler's principles for designing ideal systems are presented below.

Fundamental IDEALS Concept Principles for Designing Ideal Systems

1. Eliminate the need for the function.
2. Specify as few low-cost inputs as possible.
3. Specify as few low-cost outputs as possible.
4. Automation.
5. Automatic data handling.
6. Adaptive control.
7. Utilize personnel skills 100 percent of the time.
8. Design systems for "regulating" conditions before incorporating all possible exceptions. [Nadler, 1967].

Contrary to Nadler's IDEALS concept, an "ideal design process" requires no checklists or rules for the implementation of a perfect design product. Contrary to the expectations, an ideal design gives imagination free reign and puts no restrictions or limitations for the invention or conception of a new product. It finds no solid and static methodological basis for the work of design. In other words, designing does not follow a strict order or a fixed and predetermined program. Likewise, no restrictions from individual or group inclination intrude the design process. Design does not promote one best way of designing - one best design method, tool or media. An unfettered "environment" nourishes creativity with unlimited sources. Human or computer partnership in this design process interposes different bodies of knowledge, competing and alternative ideas. Unlimited sources, in return, extend the designer's vision.

The basis of design education is learning. Learning is the collection of knowledge on design and designing. An "ideal design education" puts no restrictions or limitations on *what, when* and *how* to learn. Design education does not take place in somewhere, but in everywhere design or designing appears. Likewise, it is not given to certain people (designers, clients, users, etc.). Everyone involved in design or designing receives design education. In this system, humans learn not what they are required to learn, but what they want to learn. In doing this, they do not utilize a single learning method. Education allows gathering and collection of a vast variety of design information from external sources. The education system makes students conscious of all the information gathering techniques and makes possible the utilization of all the techniques. It advocates experimentation - generation of alternatives. It insists upon the interaction of individual efforts rather than the isolation of individual work. In this context, a collective effort does not preclude the emergence of divergent ideas, rather it encourages the initiation, harmonization and subordination of conflicting ideas.

Current technology, methods and information are insufficient to achieve an ideal design cycle as envisioned herein. An ideal design cycle requires new and effective techniques, material, equipments, ideas and human power. In the achievement of an unbounded and limitless environment, science is compelled to discover new, dynamic and non-linear forms of information. It must rediscover what it has known before, and then present it in new forms of design knowledge. Inquiry by design must provide new information as well as help avoid what seems to be known. It must discover things that we do not now know and can not yet see. Design inquiry must make the strange familiar and make the familiar strange.

In the history of epistemology (theory of knowledge), knowledge in general is produced by scientific research studies. Research - a systematic method of inquiry - has produced the knowledge as we retain it today. Rules and restrictions for research studies have authorized the utilization of a systematic and rational reasoning and the collection of objective and unbiased information or knowledge.

As part of the history of inquiring systems, scientists have exercised something of "random research" approach. They conducted studies in circumstances when rules were ignored while their opposites were adapted. In some cases, they found "evidence" (observed report) that defended a hypothesis against all who would accept a view only if it is told in a certain way. One example of this situation is observed in the work of Sir Cyril Burt, a noted British psychologist. This psychologist recorded fictitious data in his research on the heritability of intelligence and ignored the rules for the execution of research. He defended his hypothesis with fictitious evidence [qt. in Drew and Hardman, 1987].

Science is defenseless to many such deceptive persuasions and will necessarily be so. For that reason, an ideal design inquiry should be freed from all limitations and pitfalls of such "reasoning" research studies, but can't be. Design knowledge should obey regulations and ignores them. At base, research studies should question the information used in design while inventing ways to explain it to others. Ideally, there should be no encumbrances, restrictions and rules which may inhibit or regulate design inquiry.

CHAPTER 4

DESIGN OF AN EVOLUTIONARY PROCESS

Arriving at an ideal design depends more on our philosophy and world view than on our science and technology. How we arrive at it obviously depends on our science and technology, but our ability to use them effectively depends on our philosophy and world view [Ackoff, 1974].

What is the philosophy and world view we should acquire in arriving an ideal design? In this chapter, the author speculates on operations and actions which would move design forward progressively from a less desired state (current state) to a more desired, better state (future ideals). A proposal is made on how to improve design as well as who to involve in the evolution of design.

A proposal for the improvement of design as a whole does not suggest a sequence of controlled actions or movements which would systematically be directed toward the achievement of a progression in design. Rather, it designs a process (the order of change) which would guide people who have decided to participate in evolutionary design activities. In this light, an evolutionary process is expected to accomplish the following attributes:

1. participation
2. idealization
3. planning
4. development of the social and physical environment

4.1. Participation

Participation means the interaction of individuals, their ideas, experiences and knowledge. All individuals who want to take responsibilities in the design of an ideal design system participate in this process.

In Ackoff's essay on the nature of an idealized design, he states that the redesign of a system facilitates a widespread participation of "stakeholders". In this system, those people who are potentially affected by that system participate in designing it [1974]. However, those passively involved in the system may not recognize the improvements required in it. An external participant may more clearly see the way to improvements. An integration of external and internal participants may provide an improved set of ideas, knowledge and geltasts to the design of an ideal system.

Participation is open to anyone with proficiency and skill from any system or organization. Members of interdisciplinary or cross-functional teams can be comprised of engineers, architects, computer scientists, psychologists, sociologists, anthropologists, experts in marketing and management, and a variety of other individuals who have limited information on design. The key motivator is that they anticipate interacting with each other. In this context, the designer is not be the only authority that makes a design decision. He or she is not even the final decision maker. In such instances the formal designer is the person who makes the participants more conscious of their potentials, of the impacts of alternative decisions in generating a consensus among divergent preferences.

Some designers might reject this idea and argue that their abilities will be lost or damaged when participating with others. This perturbation is described by Richard Buchanan and Victor Margolin. For them:

> "Designers have been comfortable in crossing disciplinary boundaries on their own terms and moving into the territory of other fields. However, they are not always prepared to face the challenge when others move into their territory and employ new concepts and unfamiliar methods of argument to characterize the activity of designing or the qualities of products" [Buchanan and Margolin, 1995, p.xi].

In this context, the discussion to be made is not who to design the perfection in the overall performance of the design system, but how to arrive at it.

Nadler [1967], in his ideal design of effective and logical work systems also requires the involvement of all personnel in design. In such a system, for example, in an organization (factory, office, etc.) all personnel (manager. president, officer, worker) present their ideas on how to improve that organization. All levels of personnel, with or without intelligence make real contributions to the systems design when treated as if they had the intelligence, had a willingness to work, and want to accept responsibility.

Contrary to Nadler, the author believes that not all the participants make real contributions to the design of an ideal design. If this is the case, one might ask: *Why do we allow the participation of everyone? Why bother to carry out interaction with them?*

The author presents two reasons for this approach:

1. Participation is for those most passionately interested. Participation, in this case would increase comprehension of the system as a whole, rather than making it uninteresting, invisible and unrecognizable. It can develop their interests towards greater potential effects, and thus work towards the improvement of the whole.
2. Participants will be conscious of new possibilities, desires, ideas and gestalts. Thus, it will provide greater stimulation to be creative, which is essential in the improvement of design.

4.2 Idealization

Ackoff claims that idealization is for the redesign of a system as a whole [1974]. Idealization advocates a systems approach in design and presents a focus on the characteristics of the whole rather than on the characteristics of its parts.

> "When the redesign of one part of a system is undertaken independently of the redesign of other parts, the range of alternatives which are considered to be feasible is severely limited. For example, the variety of possible changes in the living room of a house which come to mind, assuming no other part of the house is to be changed, is much more constrained than it would be if remodeling - and certainly if construction - of the house were possible." [Ackoff, 1975, p.2].

In light of Ackoff's idealization theory, the author conceives of "idealization" as an activity by which individuals define the highest state of their interest in an object or a system. To define the ultimate state of design, idealizers do not ask themselves: *What is it that we do not want?* They do not try to remove one or more messes. Because if one mess is removed others remain and new one may replace the old. If all are removed, the mess that included them as parts - the-all-inclusive-mess remains and becomes worse [Ackoff, 1974].

Another question that an idealization activity ignores is*: What individuals really want from design?* The explanation of this attitude can be found in Churchman's statement. Churchman says:

> "Stating what we really want is a very personal matter and our statements may have other aims than revealing our real wants and needs: we want to impress people, we want to keep people supporting our projects, and so on. And naturally, most of the time we don't know what we want." [1968, p.180]

Individuals may not know what they want, but they know with what they are satisfied. When everyone is satisfied with an essence of design, we would know that it is what we have wanted before or want now. In this spirit, idealization is not the delineation of what is desired or undesired. Contrary to the expectations, it is the description of a state of design with which individuals will be satisfied.

There are several reasons for idealizing design in an evolutionary design process.

1. Idealization will utilize effectively and efficiently the creative thoughts which would otherwise be lost in less successful tasks.
2. A great amount of work needs to be directed towards the achievement of a design system that will be desired by more people. Idealization will help this. People who get involved in idealization will be less prone to criticize the design which they participate in or which they helped to develop. In idealization, a great number of people can invest time, energy and creativity towards the achievement of an ideal state.
3. Idealization can encourage both technological and social innovations, and bring them together. Current technology and social science is not sufficient for the achievement of an ideal design. Investments need to be directed towards the achievement of significant end states. There may not be a single exercise of design that can succeed in achieving an ideal state. However, on the road towards the ultimate state, designers can discover and invent new and better possibilities. Idealization can lead to many successes if not an actual ideal.
4. With the interaction of participants in the design of an idealization process that is evolutionary, idealization tends to generate consensus among those who would otherwise disagree on what should be done about a system.

4.3 Planning

Idealization is preoccupied with that which appears to be impossible. Planning can help idealization by laying out a course of action that can be followed in order to achieve an ideal state. To work towards the ultimate state, planning organizes a collection of activities.

Planning determines courses of actions, practices, programs and policies. It makes decisions on the acquisition or generation of human power, machine power, materials, money and information. It determines the organizational requirements arrangements and makes decisions on how to implement and control the plans. As such, planning determines the means, resources, organization requirements and implementation techniques and makes available each of these sources. People find and transform resources (human, financial and physical). Management can help work towards the prescribed ends. Those interested in maintaining and improving the plan (manufactures, engineers, workers, etc.) can implement the decisions supportive of that plan.

In some cases, planning may not find the necessary materials, equipment or may not be able to develop the means or organizations required. In such cases, planners should not make decisions considering on parts of the design. A partial plan not only fails to improve a system, but also fails to handle the crises it generates adequately [Ackoff, 1974]. For that reason, planning should continually restate the objectives and then require immense innovations.

4.4. Development of Social and Physical Environments

An ideal design designates totally fictive construction and reconstruction of physical and social environments. Regardless, the process needs sufficient means, resources, social organizations, implementation techniques and design knowledge. Current physical and social environments, by definition, do not provide the necessary sources. For example, current techniques are not applicable to implement a "sensory" design product (a product which would sense the changes in human appetites or needs and would transform itself according to this changes).

Idealization and planning should describe all the major environmental arrangements that are necessary and desirable. With this information, those interested in developing physical or social environments (scientists, artists, managers, workers and anyone with some intelligence) should make discoveries, inventions and improvements. They should disregard all political, technological and financial constraints.

Technology is a specific way of creating new alternatives. Computer technology promises to bring us the industrial, manufacturing, engineering, architectural and social renaissance that all of us presently seek. Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), Computer Aided Architectural Design (CAAD), Computer Integrated Manufacturing (CIM), Integrated Manufacturing Systems (IMS) are all agents in the survival, prosperity and growth of the design evolution described herein.

In the conference held by the Association of Computer Aided Design in Architecture (ACADIA '95 Conference), claims that computers will improve architectural education, practice and research. Articles in the proceeding claim that computers are being developed to:

- *enable* new ways of designing and of understanding designing. Tools like Sculptor in Virtual Reality [Engeli et al., 1995] and ID'EST [Kim, 1995] are enabling the manipulation and appraisal of design decisions.
- *share* design ideas and decisions among different architects. Ideas, decisions and comments on design projects are interactively being shared through InterNET in World Wide Web [Week, 1995] and through integrated CAAD tools [Kim, 1995; Petrovic, 1995].
- *capture* ideas with the utilization of computers as a "medium" (the "partner") [Glanville, 1995].

When computer is treated as a medium, allowed to act as a partner in design, it can expand the limitations of our imagination and help explore new possibilities for improving design. Reasoning and decision making capabilities of computers can develop a sort of productive conversation with us and offer possibilities that we could not imagine. Individual computer aided tools or integrated capabilities of computers can participate in the design process like other design professionals or participants, and employ new concepts. For example, computer graphics, VR, multimedia systems and other simulation tools can enrich the ways we experience and live with our design decisions. They can offer us new possibilities to implement our designs in real or virtual environments. With these implementation techniques design decisions can attain our absolutely relative design ideals. Computers can help interact with our ideals, help evaluate them and develop a limitless and an unfettered state that would encourage the development of new ideals. Asynchronous means of multimedia communication, for example, InterNet's World Wide Web, can provide a workspace for designers where they can actively generate, share and argue design concepts without a communication overhead. A shared workspace can lessen the time and energy to produce and circulate design information. It can lessen ambiguity in design concepts and improve coordination of design participants and of the investments directed to improve design.

CHAPTER 5

CONCLUSION

In this chapter, the author provides readers a conclusion that gets down to essentials of the thesis. To achieve this, the author answers three questions:

- *Why did the author begin with this study?*
- *What is the intention of the outcome?*
- *To where does this outcome lead?*

The author has come to this thesis through an interest in the theory of design, especially in its application in Architecture, and a concern for contributions to make design and its application better. A need was felt to expand effectiveness of what we as designers and users do. This need is followed with a recognition that we, both as designers and users, deserve an increase in the effectiveness of our designs.

The author began the speculation on this topic with an idea about the evolution. This was seen as a critical problem, especially as it impacted the formulation of the nature of progress. This problem led to an equally critical problem, namely, how the evolution of design can be willfully designed.

The critical problem, with which the author began, was the development of an explicit understanding of the nature of design evolution. Chapter 2 outlined Darwinian evolutionary theory, its opponents, and their analogies in the evolutionary theory of design. The author has come to see the evolution as a process of continuous change from a lower level or simpler condition to a higher (better) state. Due to this vision, the author has outlined what might be included in a touchstone theory of legitimacy of evolving design.

In Chapter 3, the author tried to determine what is required in design and what is not. These characteristics found pernicious and insufficient for the improvement of design:

- *Inactivism* - Those approaches which resist change and fit the end to the means available.
- *Reactivism* - Those propositions that try to unmake the past (previous change) by avoiding new changes (innovations, technology and everything that brings in the new).
- *Preactivism* - Those approaches that predict the future and prepare for what is vague and invisible.

This thesis undertakes an interactivist attitude. It tries to design the future by bringing ideas on what it should be into its redesign. It idealizes design rather than forecast the future and prepare for its treats. The author tries to formulate design ideals as based on the current knowledge and understanding of our environment.

These ideals recognizes design as the subject matter of social, cultural and philosophical investigations. For that reason, design should create attention not only as a professional practice but as a subject of the social process. We should not preclude people with different talents and interest from advocating design. For example, designers, as self-named, should not be disturbed by others moving into their territory and employing new concepts and unfamiliar methods of argument to characterize the activity of designing or the qualities of products. Designers should thus play a subtle and informal role as facilitator in a participating design group. In order to allow participation, design should be expanded to accommodate divergent interests, rhetorical purposes and objectives.

The ideal design process is to establish an ultimate freedom in design inquiry, education, practice and theory. For achieving ultimate freedom, design should allow the seamless meshing of expertise and specialties. Designers should guide the process of deliberation and encourage the integration of sound contributions by other professionals. They should be educated to value other endowments. Informal and formal education should enable the designer to complement and leverage the depth of knowledge resident in other specialties. Likewise, designers of inquiring systems ought to construct a scientific practice which support imagination rather than the elimination of inconsistencies arising out of the confusions of scientists.

Liberated design participants should then begin to wonder whether they can nourish themselves with awkward behaviors as they now do. They should wonder: *What is the ultimate nourishment? Can we define it? Can we design and implement it?*

This questions will certainly take us far beyond the limits of modern science, art and technology, and their laboratories, studios, libraries and museums. But in the end we must come back to face reality. We must ask: *What can we do about design?*

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