Conceptual Diagramming: A Creative Process Forming the Material from the Imagined

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The conceptual diagram, "An Instrument of Thought"[1] incorporates within its multilayered image the synthesis, the spatial organization that generates the creative solution to the design problem; it is within the imagined concept that the material form is embodied. Conceived as a holistic system of related parts, systems and subsystems derived from perceptually gathered data, the diagram is a creative statement that demands passion and total concentration for its physical making. Unifying the mind and the body in a single focus, participation in the process affords the maker an opportunity to experience an intense "Flow"[2] of physic energy—what we as designers know as joy.

The origin of the diagram, its components, and its process of making will be presented in brief to allow for current scientific findings and theories to be explored and utilized to illuminate its underlying theoretical aspects. This information will allow the workings of the creative mind, in the process of forming from an imagined set of ideas the material, to be spotlighted as it evolved during prehistory from early to its modern human state.[3]

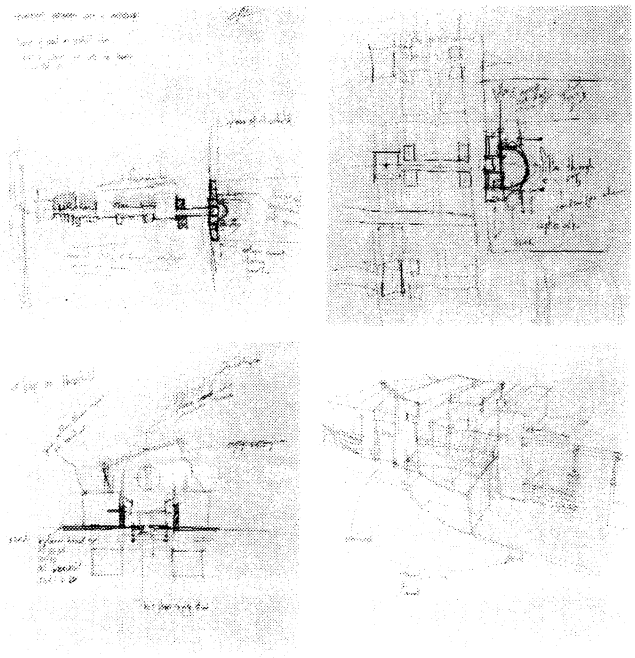

Fig. 1. Diagrammatic development of idea through graphic process to arrive at a form

THE DIAGRAM DEFINED

What Is It, and What Does It Do?

A diagram is a mental construct stated in visual terms. It represents a set of ideas that through their intrinsic relationships form a structure that can be manipulated, reworked and refined, until a holistic statement, a concept is formed. As Albarn and Smith state in their seminal text of 1977 : "The diagram is evidence of an idea being structured—it is not the idea but a model of it, intended to clarify characteristics of features of that idea. It is a form of communication which increases the pace of development, or allows an idea to function and develop for the thinker while offering the possibility of transfer of an idea or triggering of notions; finally, through appropriate structuring, it may generate different notions and states of mind in the viewer."[4]

The diagram as a means of ordering and communicating ideas has been evident since the Paleolithic era, and certainly ran rampart throughout the Neolithic period in the form of petroglyphs and pictographs, as well as sculptural forms.[5] Traditional cultures in the past communicated through diagrams, abstract signs and symbols, as they do today. It appears every profession and discipline utilizes either two-dimensional or three-dimensional diagrammatic symbol systems to comprehend and communicate their complex concepts.[6] The first recorded use (1925) of diagrams relating to the communication of design ideas might be found in Paul Klee's *Pedagogical Sketchbook*.[7] Not only were diagrams used to explain his design principles, but he attempted to capture in abstract images and in writing the inherent forces and characteristics of lines in action, with their resultant zones and spatial relationships.

The Visual Components of the Diagram

A "Graphic Language" was determined by Paul Laseau which identified point, line and zone as the alphabet of diagramming with the grammar resulting from the spatial

relationships, proximity and position of the components, along with the weight of lines connecting the ordered zones.[7] This visual vocabulary continues to be useful as a starting point in the process of developing the diagram.

In previous papers I have identified the components and relationships that might be used (in the order as stated) to develop the diagram. They are line, shape, pattern, axial structure, connections and layering (revealing spatial relationships) and figure/ground. The perceived interaction between figure and ground, negative and positive space, occurring at various levels in space, has the potential to activate the entire space to energize and to imbue the diagram with meaning through spatial interaction and dynamic tension. The designer is thus compelled to consider the totality of the visual field. A holistic statement is generated; the components create patterns, which in turn create systems that develop a structure based upon the axial order, the relationships of the related parts bind the parts to the whole. The individual parts, retain their integrity, but the focus is upon the relationships that create the harmonious system.

Diagramming: A Pattern Language

The language of pattern has been a life-long passion of Christopher Alexander who was the originator of the diagram, as we know it, within the design field. In his seminal text, written thirty years ago (1964), *Notes on the Synthesis of Form*, he stated that..."within a design problem issues interact with several others....But each issue is itself a vast problem; and the pattern of interactions is vastly complicated...there is a need to find a simpler way of writing it down, which lets us break it into smaller problems."[9] The era of information overload had begun. The need for an organizational shorthand generated diagramming.

Nearly ten years later, Alexander identified the diagram as a pattern and as being the most important aspect of his work, at the same time admitting his error in the original text.

"These diagrams, which, in my more recent work, I have been calling *patterns,* are the key to the process of creating form. In this book I presented the diagrams as the end result of a long process; I put the accent on the process, and gave the diagrams themselves only a few pages of discussion. But once the book was finished, and I began to explore the process which I had described, I found that the diagrams themselves had immense power, and that, in fact, most of the power of what I had written lay in the power of these diagrams.

The idea of a diagram, or pattern, is very simple. It is an abstract pattern of physical relationships which resolves a small system of interacting and conflicting forces, and is independent of all other forces, and of all other possible diagrams. The idea that it is possible to create such abstract relationships one at a time, and to create designs which are whole by fusing these relationships—this amazingly simple idea is, for me, the most important discovery of the book.

I have discovered since, that these abstract diagrams not only allow you to create a single whole from them, by fusion, but also have other even more important powers. Because the diagrams are independent of one another, you can study them and improve them one at a time, so that their evolution can be gradual and cumulative. More important still, because they are abstract and independent, you can use them to create not just one design, but an infinite variety of designs, all of them free combinations of the same set of patterns." [10]

The premise stated by Alexander, that a diagram has the capacity to generate alternative solutions to the given design problem from which it originates, will be discussed later when comparing the "Parti" to the concept diagram; however what is of immediate concern is the focus upon the holistic developmental aspect of the patterns.

An Holistic Approach Advocated

Rudolf Arnheim, psychologist and advocate of visual thinking, stated the following in his last text, *To the Rescue of Art,* published in 1992. "The highly structured organization of works of art insists of the need to consider the relations between whole and parts. Any successful work of art relies on an overall pattern, more often than not it is a hierarchic one. In such a pattern a dominant theme controls the subordinate subwholes. These subwholes, in turn, are not simply brought about by the dominant pattern but possess structures of their own. Their substructure gives them some self-containedness, which, however, exists only in interaction with the whole. It is an intricate principle of composition enabling works of art to function as conveyors of meaning. The same is true for biological structures such as the bodies of organisms.

"Highly organized structures of this sort serve furthermore to show that while interactive fields make their components

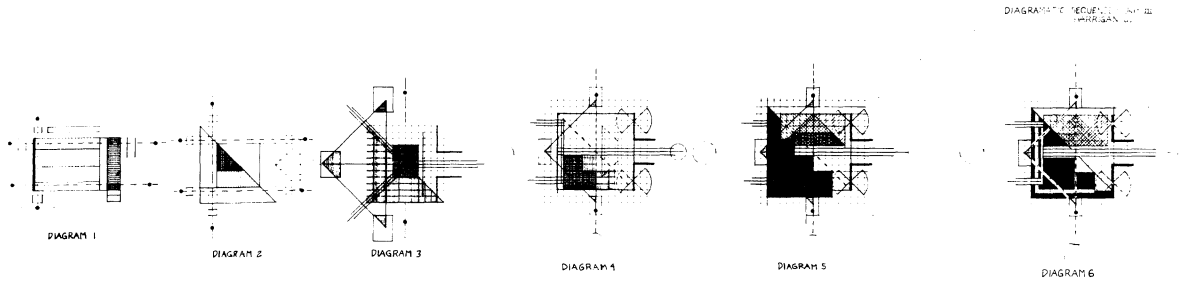

Fig. 2. The visual components and developmental sequence of a diagram have been selected and inked by the lst year student for presentation.

dependent on one another, they also counteract any plurality of appearance and meaning in the elements. In a painting, for example, the shape, brightness, and color of any part are strikingly influenced by its surroundings; but this very setting of surrounding features also keeps a firm grip on each part, stabilizing it and omitting it to the single meaning the artist has selected for it. Similarly in biology, the shape and function of each organ are strictly controlled by the body as a whole." [11]

The need to explore, and to determine the process, by which an harmonious whole is created appears to be the intent of current philosophic and scientific investigation. Fritjof Capra addressing the human condition as well as the situation evident in the field of cognitive science, both suffering, he feels, from a deep source of frustration and anxiety, concludes his latest book, *The Web of Life*, with the following: "To overcome our Cartesian anxiety, we need to think systematically, shifting our conceptual focus from objects to relationships. Only then can we realize that identity, individuality, and autonomy do not imply separateness and independence...The power of abstract thinking has led us to treat the natural environment—the web of life—as it consisted of separate parts to be exploited by different interest groups."[12] Design and design education have in the past been too concerned with the ego and object; however, it appears this focus may be shifting to holistic contextual concerns, and with this shift the need for diagramming as a tool emerges.

THE ROLE OF THE DIAGRAM IN THE DESIGN PROCESS

Exploration of Creativity and Design Methodology

Christopher Alexander's texts were published in the 1960's at a time when the study of creative thinking was being explored in earnest, including investigations of design methodology; however, by the early 70's this interest had waned. Within recent years, a solid body of research has developed.[13] Previously, creativity was considered the realm of the genius. Now, we know that creativity can be learned and certainly enhanced given the appropriate environment, and that creativity and problem solving are basically the same process, often termed CPS. Creative problem solving employs both critical and creative thinking, convergent and divergent means of thought respectively.

Research indicates the current dominant approach to the design process, or CPS as defined by researchers, is an Information Processing Theory which makes use of the computer for the gathering of data and for testing. However, Problem-Space Planning Methods are still in use. According to Peter Rowe in *Design Thinking,* Alexander's diagrammatic approach to the design process fits into this method.[14]

Analysis, Synthesis and Appraisal

Bryan Lawson, an often quoted authority in Great Britain and author of *How Designers Think*, 1990, makes use of investigations into the design process that surfaced immediately following the work of Alexander. Lawson refers to a study completed in 1969 and 1970 by Markus and Maver for the Royal Institute of Architects in Great Britain.

> "They argue that a complete picture of design method requires both a "decision sequence" and a "design process" or "morphology." Markus and Maver suggest that we need to go through the decision sequence of analysis, synthesis, appraisal, and decision at increasingly detailed levels of the design process.... Since the concepts of analysis, synthesis, and evaluation or appraisal occur frequently in the literature on design methodology it is worth attempting some rough definitions. Analysis involves the exploration of relationships, looking for patterns in the information available, and the classification of objectives. Essentially analysis is the ordering and structuring of the problem. Synthesis on the other hand is characterized by an attempt to move forward and create a response to the problem. Essentially, synthesis is the generating of solutions. Appraisal involves the critical evaluation of suggested solutions against the objectives identified in the analysis phase....Our map of the design process must allow for an indefinite number of return loops from evaluation to synthesis...."[15]

Psychological Aspects of the Design Process

The design process has as its theoretical base the psychological aspects of perception and judgment. Perception includes the employment of the five senses and intuition, while judgment utilizes thinking and feeling.[16] The psychological aspects may be positioned under Larson's subheadings in the following manner: Analysis employs perception, the five senses, thinking and to some extent intuition, while synthesis requires intuition and feeling. Appraisal most certainly utilizes the aspect of judgment, both thinking and feeling, as does decision.

Analysis Based Upon Perception: Mapping

Scientific studies published in Russian, recently translated, have proved that perception, in this case the visual aspect of perception is a cognitive function.[17] In addition, imbedded within the "Santiago Theory ...a systems theory of cognition," is the new awareness that the simplest organisms are capable of perception and thus cognition. The new concept of cognition, the process of knowing (intuition) is much broader than that of thinking. It involves perception, emotion, and action—the entire process of life,[18] as does the diagrammatic design process.

These recent findings verify the thoughts and writings of Rudolf Arnheim, who repeatedly has stated that one thinks visually. Thinking visually is the foundation of the diagrammatic approach to the design process. "Visual perception...is not a passive recording of stimulus material but an active concern of the mind. The sense of sight operates selectively. The perception of shape consists in the application of form

categories, which can be called visual concepts because of the simplicity and generality. Perception involves problem solving."[19] Arnheim continues: "Most noteworthy is the awesome complexity of the cognitive processes that must be performed in order to make adequate perception possible. The properties of any part of the visual field must be seen in constant relation to corresponding properties of the field as a whole....Quite likely it takes time to learn to see things in relation. What matters is that the cognitive process which produces the so-called constancy's is of a very high order of intelligence since it must evaluate any particular entity in relation to an intricate context, and that this feat is performed as an integral part of ongoing perception."[20]

That the object to be thus perceived must "be abstracted from its context"[21] is in direct correspondence to the process of mapping, which is often confused with the diagrammatic process. Perceptually based mapping is a valid means by which to analyze objects in a context, or the context itself, and it serves as a means by which data can be brought to the diagrammatic process for inclusion within the conceptually based diagram. But the very nature of the mapping process, their making and their reading, holds the abstracted data in a state of generalization.[22] It is cold, it is not possible for the map to feel the heat of passion as it is "fused," to use Alexander's term, to the patterned structure of the diagram. Although the map, through overlays may convey layered meaning, it can not be made to convey multilayered meaning in an holistic sense. That is the role of the conceptual diagram.

The Generating Concept: Synthesis

Conceived at the moment when it all comes together—the parts to the whole, the concept diagram still bares its intuitive roots; it has not yet taken form, but is the means by which the designer arrives at a logical form. The concept is the directing essence in visual terms.

"The more inclusive and mature the concept, the greater its gathering power—the larger the number of issues it is able to accommodate or join. A concept is more inclusive if it simultaneously addresses more issues, meets more requirements, includes more elements and affects more decisions. Every concept should seek to be as inclusive as appropriate and possible, given its place within a solution's conceptual hierarchy."[23] Flexible in nature, the concept diagram defers judgment allowing alternative solutions to take form from the imagined. Thus, the conceptual diagram differs from the "Parti." According to Benedict, the "Parti" indicates choice, it records the selected form. The Parti embodies the solution to the design problem in embryonic terms, it reveals the form in a reduced state. The concept diagram is the D.N.A. that has the capacity to form the Parti.

THE DIAGRAMMATIC APPROACH TO THE DESIGN PROCESS

When employed within the design process, diagrammatic methodology provides the vehicle for gathering data, analyzing and ordering the data, stating the problem with its constraints of forces and programmatic issues, and through manipulation of the data developing an organizational system from which springs forth the designer's concept that has the capacity to generate the problem solution.

Approach Initiated by Christopher Alexander

Christopher Alexander has written that once the complete structural description of the design problem is defined it serves as a program for the synthesis of form which solves the problem. The diagram must do two things; it must serve as a graphic means to set the requirements and find the form.

As a requirement diagram:

a. It must bring out just those features of the problem which are relevant to this set of requirements.

b. It must include no information which is not explicitly called for by these requirements.

As a form diagram:

a. It must be so specific that it has all the physical characteristics called for by the requirements.

b. Yet it must be so general that it contains no arbitrary characteristics, and so summarizes, abstractly, the nature of every form which might satisfy (the problem).[24]

The following excerpt was extracted from Alexander's writing by Peter Rowe.

"First, the problem as given is restated in a form consisting of numerous discrete problem statements. In other words, it is described in terms of its singular constituent elements rather than by broad organizing principles. (Second) identifiable aspects of the problem having some bearing would be related to one another. Third, very closely interrelated groups of problem statements are identified, thus defining the most basic level of design subproblems. Forth, the subproblems isolated in this manner are combined, using the pertinent relational information, usually in a hierarchical stepwise fashion. This process of combination culminates in a single problem statement that is inclusive of all subordinate statements...In short, the procedure allows decisions made by a designer about parts of a problem, and about their interrelationships, to be systematically structured so as to produce an explicit picture or diagram of the problem space at various levels of generality. Finally, this structure can be further exploited in order to identify those aspects of particular subproblems of interest that seem to have the most controlling influence over the configuration of the problem space." [25](Rowe quotes Silverstein and Jacobson, in "Restructuring the Hidden Program: Toward an Architecture of Social Change." in Wolfgang

F.E.Preiser, ed., *Facility Programming*. Strousburg, Pennsylvania: Dowden, Hutchinson and Ross, 1978).

Implementation in the Studio

During the past twenty years, a diagrammatic approach has been formulated and implemented by a number of faculty in the studios of the University of Florida. However, the division of the execution into successive stages was devised by the author to introduce the method to beginning students.

Relationships are sought within the data provided by the problem statement; this information forms classification diagrams that resemble Alexander's "Tree Diagrams." As issues and their responsive ideas are determined they are hierarchically ordered using shapes and lines with their appropriate connections to form systems and subsystems that create patterns. The developed programmatic needs and wants, both quantitative and qualitative issues, are woven into the diagram including the information identified in the initial simple diagrams.

Site-analysis determines the forces inherent in the given context; when worked into the second diagram they begin to define the axial structure. The two diagrams are manipulated to form one—an organizational diagram, which must be explicit with its shapes and spaces informing each other as they gather about the axial structure.

This diagram continues to evolve in response to both creative and critical thinking. A dialogue continues between the student and the diagram where design decisions are visible allowing immediate feedback and manipulation by means of transformation, transfusion, translation and transposition.[26]

While reworking the diagram the student's intuitive response generates the spatial organization. In a creative leap, while engrossed in the continual manipulation process,

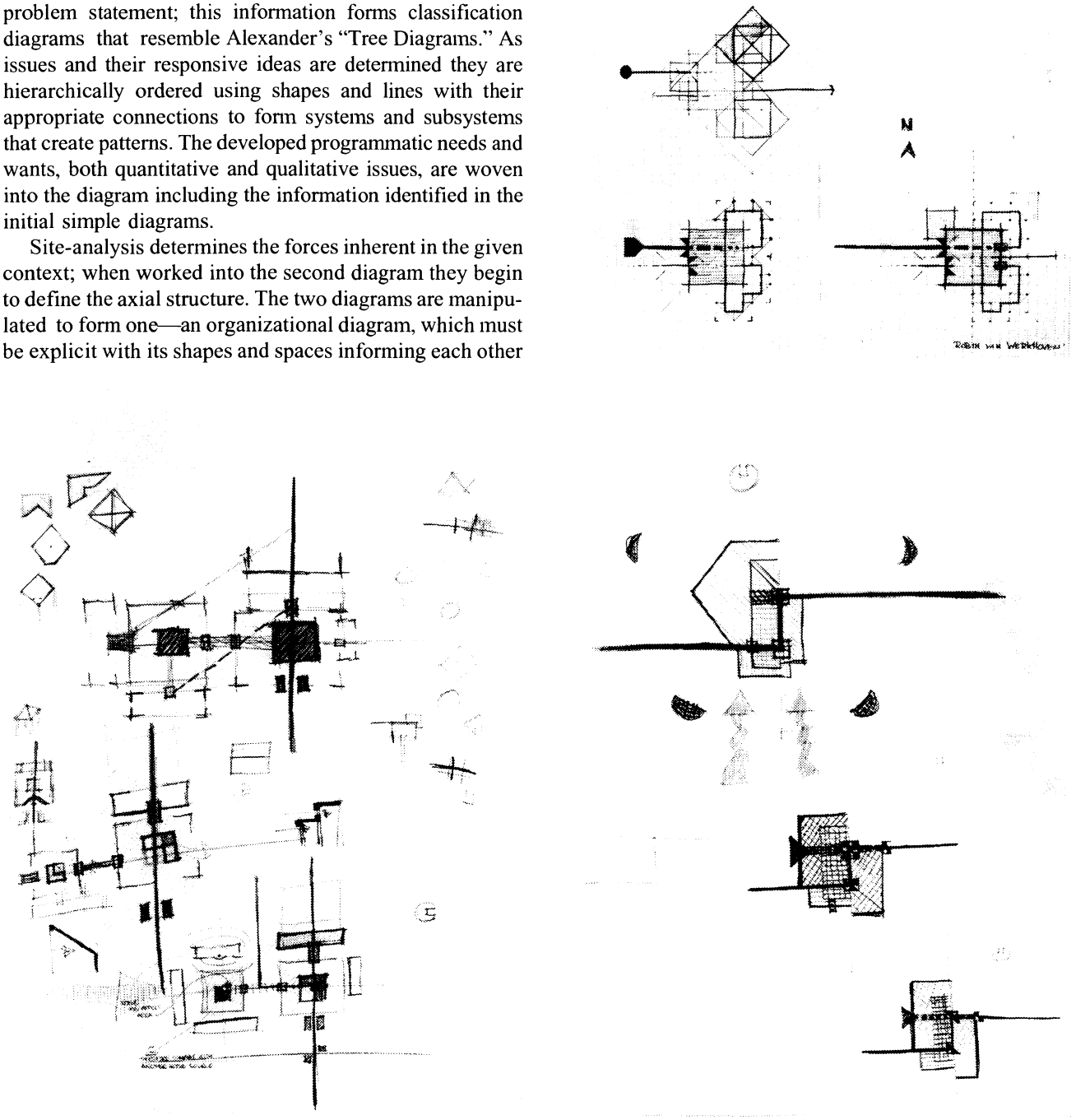

Fig. 3. Transformation of a diagram in increments, lst year student work.

the concept is found; it embodies the imagined set of innovative ideas necessary to solve the problem and find the form. Caught at the moment of passionate conception, the holistic diagram radiates with the student's creative energy. Such a moment, the designer strives for. It is the reward for the painstaking data collecting, and its power will propel the designer through the seemingly endless process of execution until the state of evaluation can occur.

Involvement provides "The Optimal Experience"

The process of physically making the concept diagram is totally absorbing. Both sides of the brain, the whole brain, or rather the mind is drawn into the activity, as the mind has now been determined as the process, and the brain the structure within which the cognitive process occurs. "Mind and matter no longer appear to belong to two separate categories but are seen representing merely different aspects, or dimensions, of the same phenomenon."[27] The body, the senses, and the emotions are captivated by involvement in the diagrammatic design process. Time and space disappear, the involvement is physically exhausting but emotionally exalting. This state is exactly what has been termed the "Optimal Experience" by Mihaly Csikszentmihalyi in his bestseller "Flow." The author, a renowned researcher of the creative process, states "The best moment occurs when a person's body or mind is stretched to its limits in a voluntary effort to accomplish something difficult and worthwhile. (It is) the state in which people are so involved in an activity that nothing else matters; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it."[28] He continues, perhaps with greater insight into the involvement required by a diagrammatic approach to the design process, "...overwhelming proportion of optimal experiences are reported to occur within sequences of activities that are goal-oriented and bounded by rules—activities that require the investment of psychic energy and that could not be done without the appropriate skills."[29]

DIAGRAMMING PROVIDES A CREATIVE FRAMEWORK

The "Optimal Experience" is the reward of passionate involvement in a creative endeavor. A diagrammatic approach to the design process is an endeavor that encompasses the "ingredients of creativity,"as defined by Frank Barron, a designer who has recorded his insights in a paper, "Putting Creativity to Work." He defines these ingredients: (1) Recognizing Patterns, (2) Making Connections, (3) Taking Risks, (4) Challenging Assumptions, (5) Taking Advantage of Chance, (6) Seeing in New Ways."[30]All of which are encouraged by participation in the diagrammatic process.

Involvement also utilizes the "Frame" of Spatial Intelligence as outlined by Howard Gardner in *Frames of Mind, A Theory of Multiple Intelligence.* He states "In light of numerous tests...it seems reasonable to nominate spatial intelligence as a discrete form of intellect, a collection of related skills."[31] "Central to spatial intelligence are the capacities to perceive the visual world accurately, to perform transformations and modification upon one's initial perceptions, and to be able to re-create aspects of one's visual experience, even in the absence of relevant physical stimuli. One can be asked to produce forms or simply to manipulate those that have been provided."[32]

Gardner's work has provided a substantial influence in various areas of research, including anthropology and archaeology, specifically in the study of symbol emergence and its use as communication. Steven Mithen writes in The *Prehistory of the Mind*, 1996, that although humankind has existed on earth for the past 100,000 years, a dramatic change took place in the working of the human mind between 60,000 to 30,000 years ago. He speculates that this change was in response to a force or need since earth's inhabitants were living under extreme stress brought about by harsh climatic conditions. Their environment as they knew it was changing rapidly; they were faced with extinction. In order to survive they had to adapt.[33] "Creativity is an ability to respond adaptively to the needs for new approaches and new products."[34] This is exactly what happened, and what must happen again.

Until this time early man's mind was compartmentalized, there were virtually no connections or overlapping of Gardner's "Frames of Intellect." With the first crossover of one Frame to another, the capacity to create symbol systems with the intention of communication became a universal attribute of the modern human's mind. The emergence of this system of communication, with all the aspects of diagramming, changed the course of humankind.[35]

Christopher Alexander, concerned with the need for social change and the information overload, believed the creative power of the diagrammatic symbol system could induce adaptive activity. Today, computer technology is rapidly moving us into an elevated stage of stress and overload. "Creativity is not just an ability but a characteristic of evolving systems."[36] We must evolve in order to survive. Although the computer can identify, classify, map and document, it does not possess intuition and feeling. It can not create a conceptual diagram. It can not become passionately involved in the process, or feel the joy of discovery, the "Optimal Experience."

Although the diagrammatic process is not new, it is new to some, and to others it has seemed too difficult to implement. This paper attempts to make the process known, and to encourage its use in the design studio where it can form the material from the imagined.

NOTES

[1] Keith Albarn and Jenny Miall Smith, *Diagram The Instrument of Thought* (London, Thames and Hudson, 1977), 7.

[2] Mihaly Csikszentmihalyi, *Flow The Pyschology of Optimal Experience* (New York, Harper Perennial, 1991)

[3] Steven Mithen, *The Prehistory of the Mind the cognitive origins of art, religion and science* (New York, Thames and Hudson, 1996).

[4] Albarn and Smith, *Diagram The Instrument of Thought,* 7.
[5] Mithen, *The Prehistory of the Mind,* 151-184.
[6] Rudolf Arnheim, *Visual Thinking* (Berkeley, The University of California Press,1971) 139.
[7] Paul Klee, *Pedagogical Sketchbook* (New York, Frederick A. Praeger, Inc., 1964)16-60.
[8] Paul Laseau, *Graphic Thinking for Architects and Designers* (New York, Van Nostrand Reinhold Company, 1989) 55-68.
[9] Christopher Alexander, *Notes on the Synthesis of Form* (Cambridge, Harvard University Press, 1971)3.
[10] Alexander, *Notes on the Synthesis of Form,* Preface.
[11] Rudolf Arnheim, "Interaction"*To the Rescue of Art: Twenty-Six Essays* (Berkeley, University of California Press, 1992)195.
[12] Fritjof Capra, *The Web of Life* (New York, Anchor Books, 1996) 295.
[13] Frank Barron, "Putting Creativity to Work" in ed. Robert Sternberg *The Nature of Creativity Contemporary Psychological Perspectives* (Cambridge, Cambridge University Press, 1988)77.
[14] Peter G. Rowe, *Design Thinking* (Cambridge, Massachusetts, The MIT Press, 1987) 55.
[15] Bryan Lawson, *How Designers Think* (Boston, Butterworth Architecture, 1990) 27.
[16] William Voelker, "Psychological Aspects of the Design Process," *CRIT15 The Design Process* (Washington, D.C., American Institute of Architects Students, Inc.,1985) 6-11.
[17] Vadim D. Glezer,*Vision and Mind Modeling Mental Functions* (Mahwah, New Jersey, Lawrence Erlbaum Associates, Inc.,1995)
[18] Capra, *The Web of Life,* 175-6.
[19] Rudolf Arnheim, *Visual Thinking* (Berkeley, The University of California Press,1971) 37.
[20] Arnheim,*Visual Thinking,* 40.
[21] Arnheim,*Visual Thinking,* 38.
[22] Arnheim, "The Perception of Maps" *New Essays on the Psychology of Art* (Berkeley, University of California Press,1986, 194-202).
[23] William Benedict and Donna Duerk, "Concepts: The Studio's Essential Content" in *The Design Studio in the 21st Century: Proceedings of the 1992 ACSA West Regional Meeting* (San Luis Obispo, California, Architecture Department, College of Architecture & Environmental Design, 1992)1-4
[24] Alexander, *Notes on the Synthesis of Form.* 126-127.
[25] Rowe, *Design Thinking,* 25.
[26] Albarn and Smith, *DiagramThe Instrument of Thought*, 26.
[27] Capra, *The Web of Life,* 176.
[28] Mihaly Csikszentmihalyi, *Flow The Pyschology of Optimal Experience* (New York, HarperPerennial, 1991)3-4.
[29] Csikszertmihalyi, *Flow The Psychology of Optimal Experience*, 48.
[30] Barron,*The Nature of Creativity*, 80.
[31] Howard Gardner, *Frames of Mind The Theory of Multiple Intelligences* (New York, Basic Books,1983/1993) 177.
[32] Gardner, *Frames of Mind,* 173.
[33] Mithen, *Prehistory of the Mind,*151-165
[34] Barron, *The Nature of Creativity,* 80.
[35] Mithen, *Prehistory of the Mind,* 151.
[36] Barron, *The Nature of Creativity,* 80.