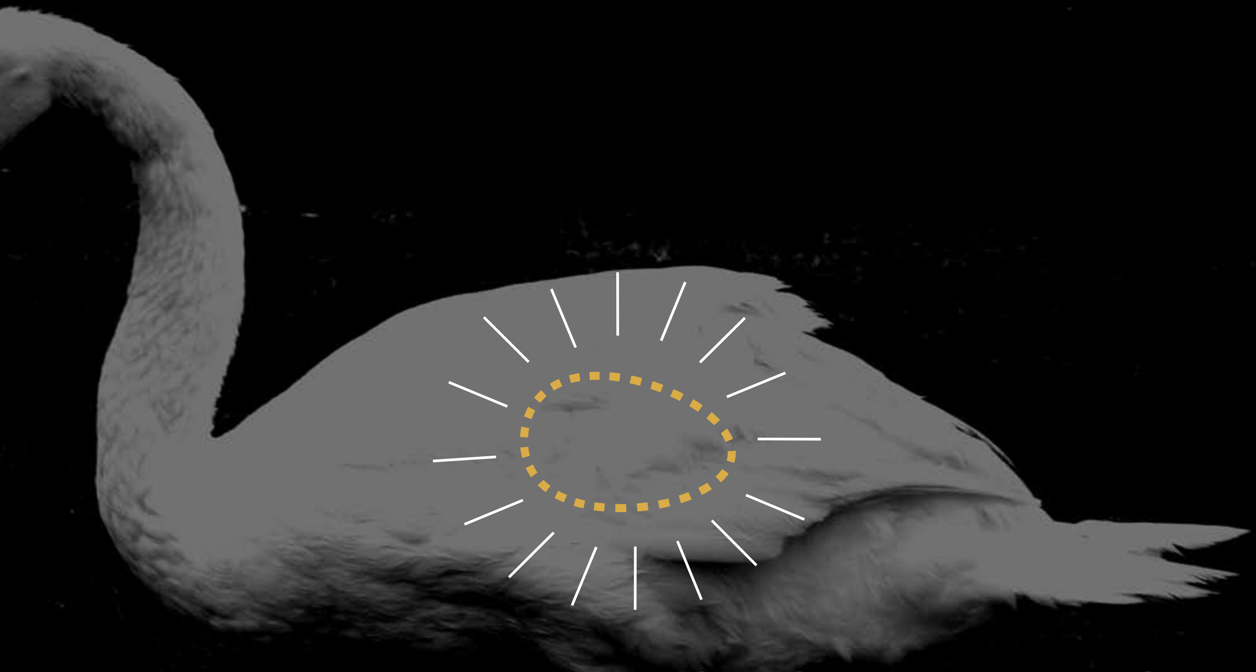

LOOKING IN

AN EXAMINATION OF DESIGN AS METHOD

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Mark Parson / Masters Thesis / Design

Thesis Committee
Axel Roesler Ph.D. / Chair
Christopher Ozubko / Advisor

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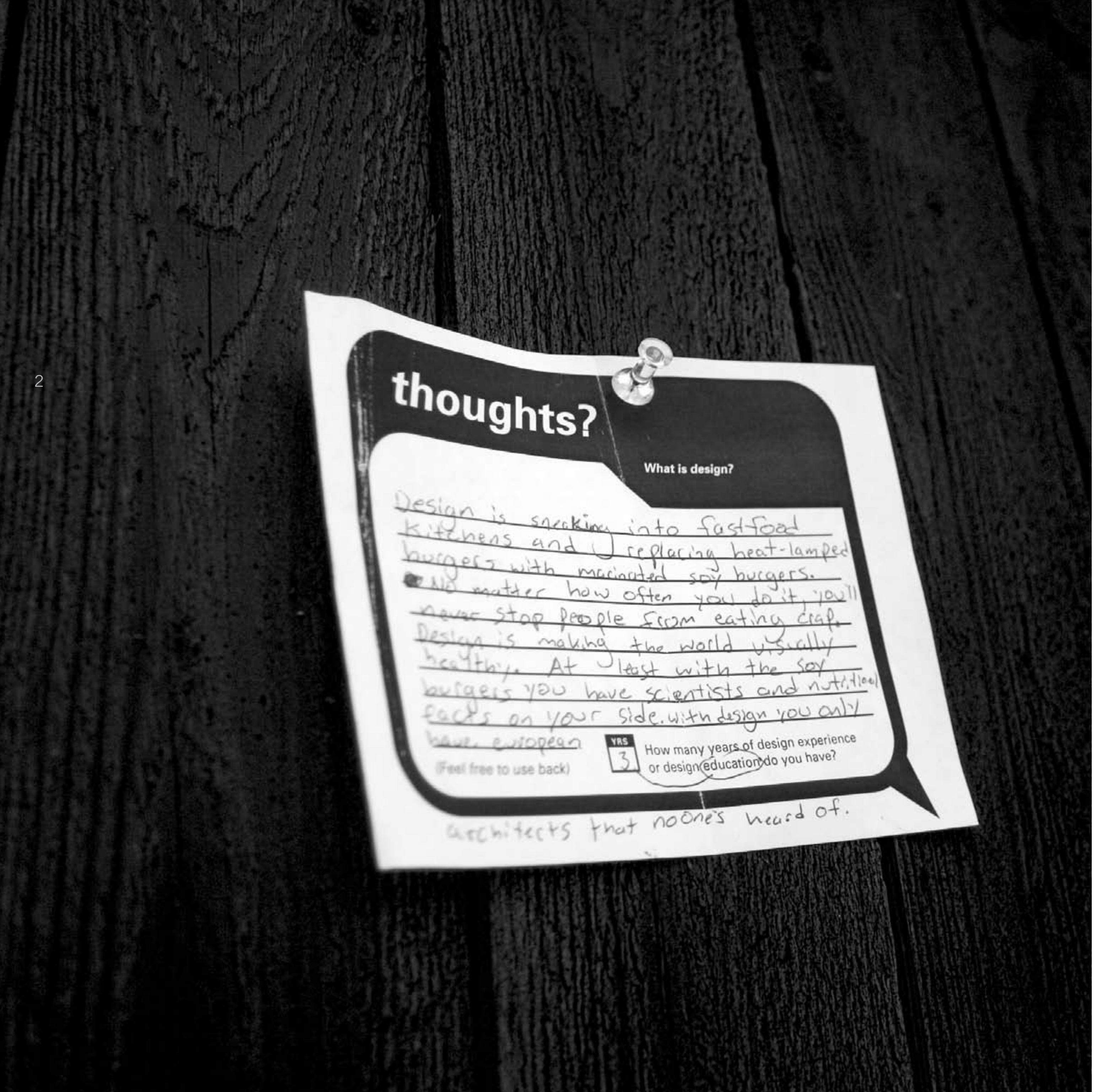
for Elizabeth

Table of Contents

Part One: Complexity and Coordination

No design can exist in isolation. It is always related, sometimes in very complex ways, to an entire constellation of influencing situations and attitudes. What we call a good design is one which achieves integrity – that is, unity or wholeness – in balanced relation to its environment. The reason good design is hard to come by is that its creation demands a high degree of emotional and intellectual maturity in the designer, and such people are not found too often.

George Nelson



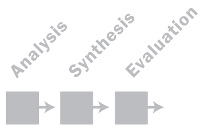
Why examine design analytically? After all, designers have done very well without such for many decades. As long as the goose continues to lay its golden eggs, why risk a peek inside? This sentiment is a common one which Christopher Alexander sums up explaining, "There is a good deal of superstition among designers as to the deathly effect of analysis on their intuitions – with the unfortunate result that very few designers understand the process of design analytically." (Alexander, 1964) However, design problems are growing increasingly complex, requiring a deeper understanding of design as a process. This is accomplished through the development of methods that can be formulated, shared, and repeated.

In scenarios where great technical effort is required to accomplish a design task, the Design can be overlooked in deference to the difficulty of engineering a functional solution. To this point, graphic designers are increasingly finding themselves at the tail end of projects, especially with regard to interactive work. Seen as frosting specialists, they are handed final aesthetic choices rather than integral design decisions. They are often expected to make complex systems work through color and font choice. While designers are very good at clarifying information and increasing legibility, their greater value lies in their ability to discover innovative solutions. Therefore, by examining designer's knack for innovation, we hope to explain why designers are a valuable addition at earlier stages in the problem solving process.

There are almost as many design definitions as there are designers. Some see design as communication, others see it as idea making. Outside the design community, most people seem to associate it with computers.

Design automation

Many designers are skeptical of systematic procedural methods because they can quickly begin to smell of design automation. However efforts to automate design have met with difficulty. In the 1960's, early design methodologists



The Three stage design process - J. Chris Jones

influenced by the introduction of the computer as a problem solving aid, sought to develop methods for successfully applying raw computing power to design problems (in much the same way that astronomers and molecular biologists were successfully crunching large data sets). They discovered that design problems resisted conventional artificial problem solving applications. This lead to the important realization that design problems were in themselves a singular type of problem, and that designers addressed them with unique and unconventional techniques.

The Design Process

The design process is typically divided into a series of phases of differing purpose. These phases progress sequentially from the reception of a statement of need to the delivery of some artifact designed to address that need. In this sense, designers are situation improvers. The design phases typically begin with some form of research, followed by research analysis and issue identification, formulation of solution concepts, and finally the synthesis of disparate elements into a physical artifact (see Jones, 1963 and Archer 1965 for the classic descriptions of a 3-stage design process). While such linear models do describe the general motion and benchmarks of the design process, most projects tend to defy such clean divisions and sequencing. Furthermore, there is a hidden danger in specifying the way the designer moves through the process. By forcing certain linear steps, the designer's ability to innovate might by compromised. Designers are hired for their somewhat mysterious ability to think *unconventional and unexpected thoughts*. Therefore, progress tends to move in unexpected and often counter-intuitive ways. *Designers know* innovation often occurs when pursuing this type of direction whose value is not initially evident. Designers are most valuable when they conceive,

The design process in a nutshell

ORGANIZATION

Identify the statement of need, and outline a plan for addressing it.

RESEARCH

Identify key elements and begin deeper analysis of issues.

IDEATION

Generation of ways to address the need. Begin forming problem.

FORM GIVING

Giving ideas spatial form and physical relationship.

REALIZATION

Transition from plan into physical reality.

not what is or can be predicted, but what m*ight be* and *is yet unforeseen*. In this sense, they need the freedom to walk in undefined paths. However, designers recognize the necessity of supervisory direction, for without clear objective and constraints, they cannot produce work that is relevant. This need for order increases drastically when working in a team. It appears that we have two mutually exclusive requirements: on the one hand, the freedom to innovate, and on the other, supervisory structure. Isaac Asimov echoes this dilemma,

> "Research... forced into predesigned patterns [becomes] slavish and [has] to stagnate. Yet... no one would advocate running a factory by allowing each individual worker to do whatever pleased him at the moment, or of running a ship according to the casual and conflicting notions of each individual crewman... some sort of centralized supervisory agency must exist in each case...

> "When science was young and the intricacies of all or most of the known was in the grasp of an individual mind, there was no need for direction, perhaps. Blind wandering over the uncharted tracts of ignorance could lead to wonderful finds by accident.
>
> "But as knowledge grew, more and more data had to be absorbed before worthwhile journeys into ignorance could be organized. Men had to specialize. The researcher needed resources of a library he himself could not gather." (Asimov 1957)

Design is a group activity. The increasing breadth of technology is turning formerly simple design tasks into complex ones. One person can no longer do it all alone. Because complex tasks require the cooperation of specialists during all design phases, a common language is needed to coordinate their activity. Multidisciplinary teams desperately need better communication, coordination, and attack structures to address these increasingly complex problems.

In contrast, most traditional graphic design tasks could be undertaken by the single individual. For instance when designing a poster, it is not uncommon for one person to research the issue, generate ideas, sketch thumbnails, and produce the final design. There is little difficulty coordinating one's efforts with oneself. However as the scope and complexity of design problems increase, the breadth of the design process can no longer be encompassed by one brain or one skill-set.

Wicked Problems
Most Design problems contain a class of characteristics that identify them as wicked problems. These types of problems are underspecified and ill-constrained, First described in a design context by Herbert Simon as ill-defined problems (Simon, 1973). Rittel and Webber then coined them: Wicked.

Research... forced into predesigned patterns [becomes] slavish and [has] to stagnate. Yet... no one would advocate running a factory by allowing each individual worker to do whatever pleased him at the moment, or of running a ship according to the casual and conflicting notions of each individual crewman... some sort of centralized supervisory agency must exist in each case...

The issue of order and chaos is a recurring theme in the formal realm of design as well as the organizational realm. Striking a balance between these force is sometimes called repetition with variation or unity plus variety

Wicked problems are those that seem to defy clean or systematic resolution. Consider some of the hallmarks of wicked problems.

1 Solutions to wicked problems are not true-or-false, but good-or-bad

2 There is no ultimate test of a solution to a wicked problem

3 Wicked problems do not have an enumerable or describable set of potential solutions.

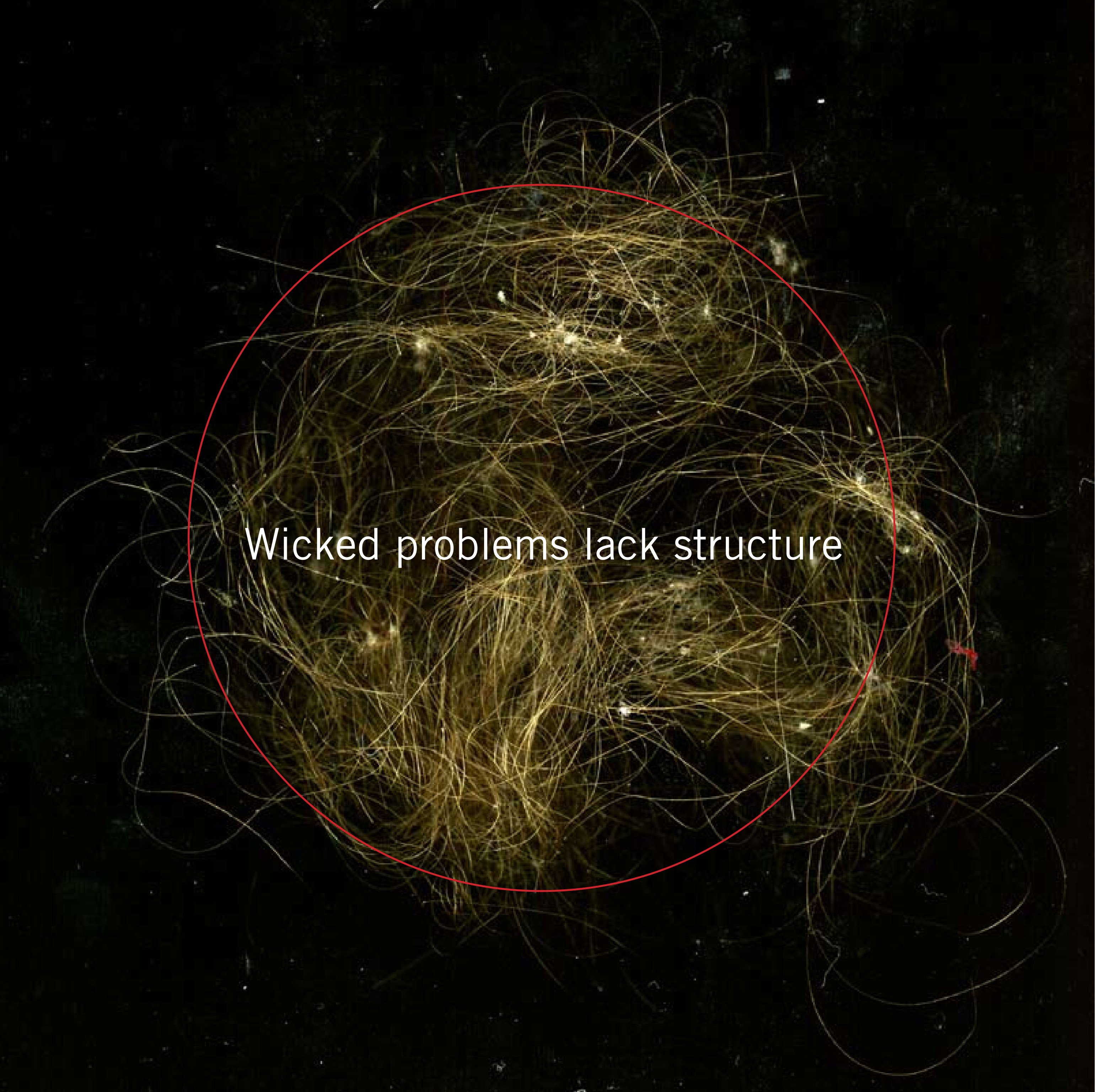
4 Every wicked problem is unique

5 A wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution. (Rittel&Webber,1973)

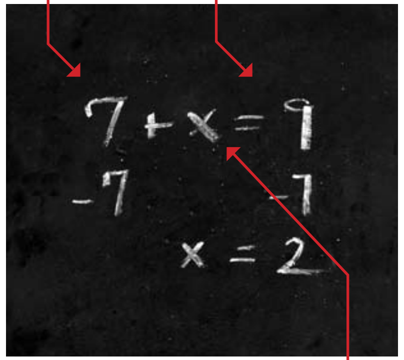
Despite the sticky challenge wicked problems present, designers are especially adept at resolving them. Because wicked problems have no definitive shape, designers are forced to give them shape and identify themes of meaning. This is like chess grand masters who can see patterns of development and discern eventualities from limited information without performing exhaustive individual move calculations as a chess program would. Designers are able to recognize patterns in underspecified problems, and extrapolate successful forms despite the problem's indeterminate nature.

However, the scale of the wicked problem affects the designer's ability to address it. Large problems cramp flexibility due to the unwieldy nature of multi-individual coordination. On the other hand, small wicked problems can be attacked with flexibility because they contain a relatively small number of interacting parts. Their relative simplicity allow the designer to maintain the big picture in her head throughout the entire process. She can weigh any radical departure from the expected against the higher aims of the project. Furthermore, she is able to evaluate the implications such deviations present to the other design phases. This flexibility allows the designer to redefine the problem itself without compromising consistency or cohesion. However when resolving large problems where the entire process cannot be undertaken by one individual, some sort of responsibility division is inevitable. In this situation, unconventional exploration and problem redefinition by the individual can be dangerous. When multiple efforts are progressing simultaneously there must be some assurance they will converge in an anticipated location at some specified point in the future.

This class of large wicked problems are especially evident in the growing trend of super teams composed of specialists from multiple disciplines. However despite boosts in resource, wicked problem solving is frequently



By giving a wicked problem tangible form, the designer also specifies the nature of the solution. Therefore, the problem definition should receive as much attention as the problem solution.



plagued by less than ideal results. Adding fuel to the engine isn't improving accuracy, rather, it is increasing speed along incorrect trajectories. The greatest problem is not one of resource, but one of organizational flexibility and shared vision. How can the individual designer's ability to identify the promising aspects of a wicked problem, nature be applied to larger groups?

Forming the problem is the problem

The defining hallmark of a wicked problem is its lack of form and objective structure. Remember, "[it] can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution." (Rittel & Webber, 1973) In other words, not only should the solution be a product of creative thought, but the form given to the problem itself should also be given creative attention!

In this light, consider that traditionally when designers use the term problem, they usually mean the statement of need provided by the client (for instance, "We need a logo"). Conventional design thinking dictates the designer provide a solution which "fixes" this need. However, a vague statement of need leaves ambiguity concerning what should be done. What shape should the correct solution take? What objective metrics that can be used to test the solution? How do designers know if they even are solving the right problem? Consider the words just used: ‘objective metrics’, ‘right problem’, ‘correct solution’. Each of these terms imply that there is an objective answer to every problem. However design solutions are measured in qualification rather than metric satisfaction. This is the very reason why design differs from linear and well-defined constraint spaces where success can be measured. In Design, the outcome might be different from what was expected, but nevertheless fulfill (if not exceed) expectations. Therefore, it is difficult to predict what the product of the design process should be before the design process is actually undertaken. Alexander described the ethereal nature of Design explaining, “We are searching for some kind of harmony between two intangibles: a form we have not yet designed, and a context we cannot properly describe.” (Alexander, 1964.)

The first intangible, “the form we have not yet designed”, is equivalent to the “solution” Therefore, the second intangible, “a context we cannot properly describe”, can be understood as the problem. It is clear that the purpose of design is to create tangible solutions, but consider that another primary purpose of design is to give the problem tangibility. Therefore, “The formulation of a wicked problem is the problem! The process of formulating the problem and of conceiving a solution (or re-solution) are identical, since every specification of the problem is a specification of the direction in which a treatment is considered” (Rittel & Webber 1973) Of necessity, designers must become not only expert problem solvers, but also expert problem storytellers. Design is giving nebulous problems flesh and blood.

The term problem is almost as ambiguous as the term design. On a macro scale, a problem is the presentation of a set of challenges requiring some sort of resolution. On the micro scale, problems are stories describing in detail yet unknown solutions. In this micro sense, problems can be understood as specifications. For instance, consider the micro problem 2+1=x. Note, all of the information describing the unknown “x” are embedded within the problem’s structure. The numbers 2 and 1 tell us what quantities we are dealing with, and the plus sign tells us what we should do with these quantities. Micro problems are possible because the problem and the solution are the exact same entity. In other words, the expressions on either side of the equal sign are equivalent. Though this may seem like an obvious point, consider the implication of problem/solution equivalency, the phrasing of the problem (the context) effectually locks the solution (the form) into a predetermined path.

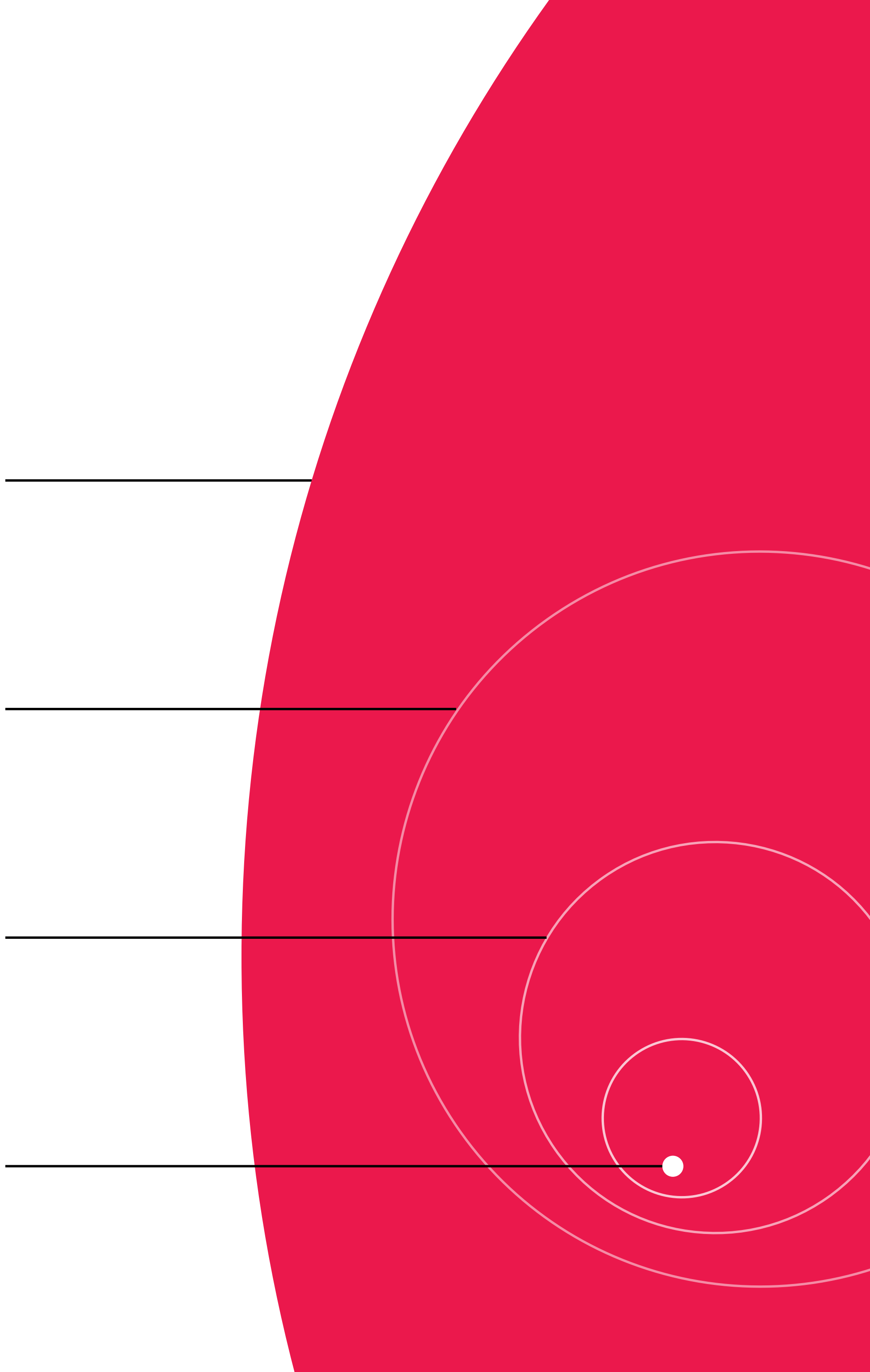
Unless macro problems are given micro form, they cannot be solved with precision. We call this problem decomposition; the act of decomposing a larger system

The World
The background against which the problem space must be delineated

Problem Space
Everything with any relevance to the issue at hand

Macro Problem
The vague statement of need

Micro Problem
A specific set of objectives coupled with a specific set of constraints



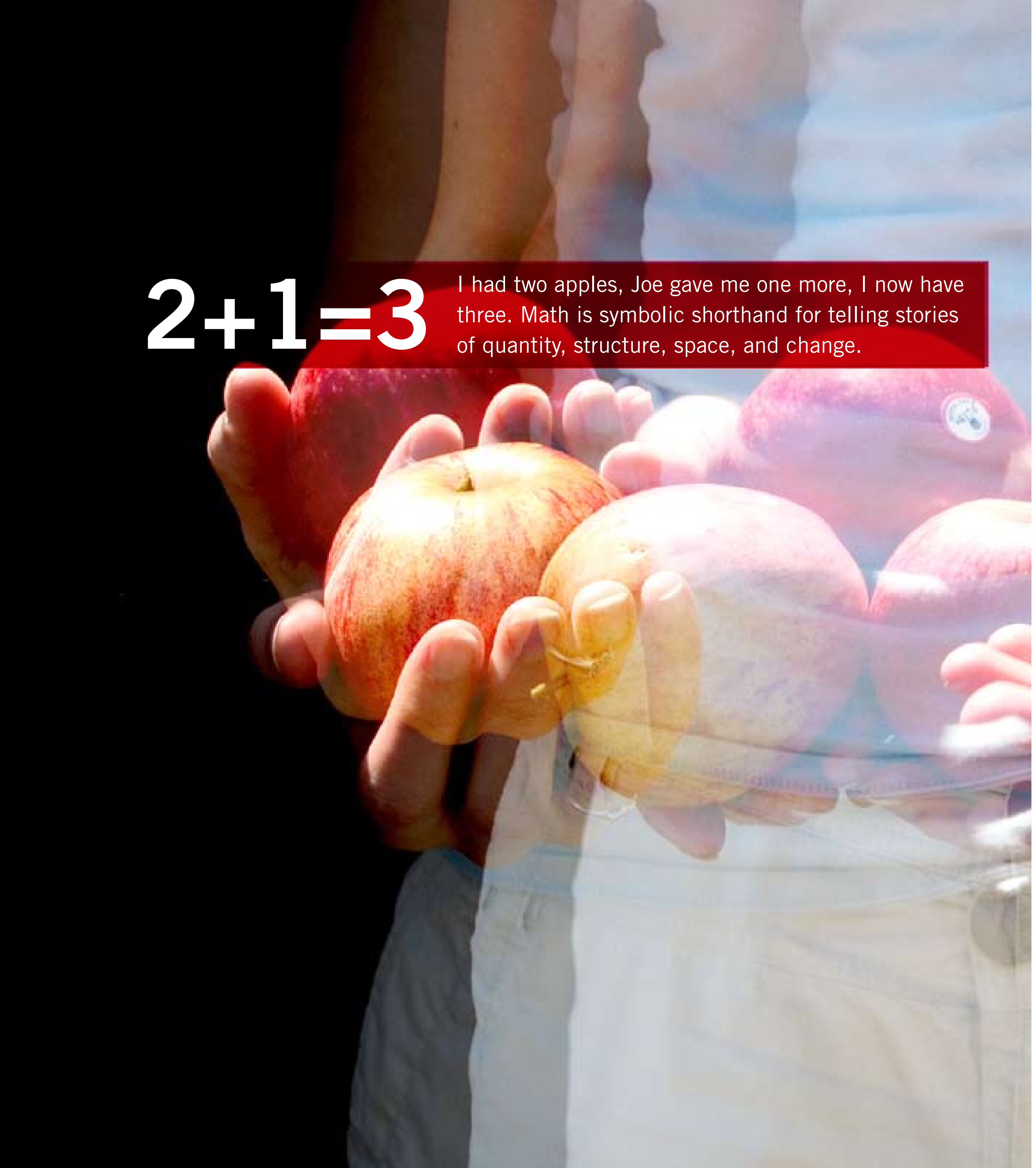
into smaller more manageable sub-systems. Again consider the simple equation 2+1. Remove any element from the expression, and the means for resolving it is complicated. Suppose that the problem was stated as “2 1”. Without the plus symbol, there is ambiguity concerning what is really needed here. Do these numbers describe a position on a graph? Should they be combined in some way with an operator (+,-,/,*)? Deeper investigation into the context of the incomplete expression would be required to solve this expression. In such cases, problem formulation as well as problem resolution is required. A well specified problem (or micro-scale problem) is a specific set of constraints coupled with a specific set of objectives. While designers view designing as the resolution of macro problems, engineers typically think of designing as the resolution of micro problems . Engineers are very good at translating a set of specifications into a functioning artifact which meets those constraints. On the other hand, designers are very good at giving problems shape in the absence of specifications

However, the role of problem constructor also carries the burden of accountability. When there are no specifications or metrics yet in place to justify decisions, the designer must explain not only why a solution is correct, but how the very problem statement they have formed is appropriate. Because there are an infinite number of ways to phrase the problem, each determining the nature of its solution, the designer must identify the core issues when constructing a problem. He must pay special attention to conflicting requirements that appear to be mutually exclusive.

Opposite page: living space designed by Le Corusier

“If he is a good designer, the form he invents will penetrate the problem so deeply that he not only solves it, but illuminates it. A well designed house will not only fit its context well but also illuminates the problem of just what the context is, and thereby clarifies the life which it accommodates. Thus Le Corbusier’s invention of new house forms in the 1920s really represented part of the modern attempt to understand the twentieth century’s new way of life.” (Alexander, 1964)

We know that complex wicked problems require division between experts. However, the act of dividing the problem into sub-problems can sometimes result in premature overspecification and commitment to wrong directions. Therefore, how can systemic cohesion be maintained without destroying innovation through



0 1 2 3 4
5 6 7 8 9

Math is a language composed of abstract universal symbols such as numerals, variables, operators, etc.

overspecification? Remember, the strength of the individual designer working on a simple problem lies in her ability to redefine the problem and evaluate its redefinition against the greater aims. Can complex problems be attacked with similar flexibility? Essentially, can a group of designers begin to respond with the flexibility and adaptability of a single organism? For this to occur, individuals need some form of shared consciousness–an external systemic representation of the problem. This shared consciousness can take tangible form through problem modeling.

Problem representation affords idea sharing

This idea of representing a complicated problem in a systematic way is at the very heart of science and math. Again consider the problem 2+1. This problem is the abstract representation of the functional operation of some actual occurrence. For instance, I had two apples, Joe gave me one more, I now have three. Math is symbolic shorthand for telling stories of quantity, structure, space, and change. With this symbolic language, we can predict potential activities and evaluate their implications before the fact. Most importantly, notation gives multiple individuals a shared understanding of the problem. Thus complex problems, such as a putting a man on the moon, can be neatly divided among specialists without sacrificing cohesion. Math abstracts interactions into universal symbols where solution focused functions may operate. When viewed this way, it is easy to see why design would benefit from a similar system for abstracting design problems. Design science, like conventional science, would allow functional analysis of potential design solutions and pre-evaluation of harmonic fit.

Sketching is to design what math is to calculation

Because design problems are wicked problems, the effectiveness of any particular solution is debatable and subject to individual perspective. This subjectivity of correctness prevents the division of design problems into universal symbols. Most importantly, the development of a design science is frustrated by this lack of a symbolic language. Scientific systems rely on unambiguous symbolic notation, and without a language of notation, complex ideas cannot be saved or transferred cleanly. For instance, imagine trying to pass an understanding of Einstein's matter energy equivalency, $E=MC^2$, without a language of notation. In the absence of mathematical expression, such ideas take the form of vague narratives full of verbal approximations of abstract meaning. Such is the state of design.

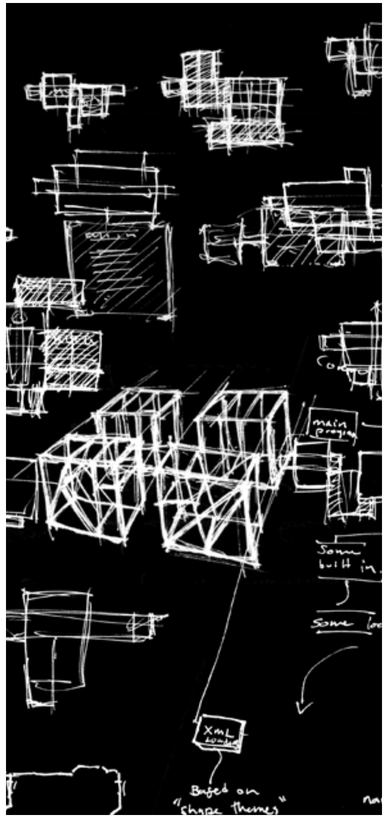
Instead of laying foundations for a notation of design by documenting design patterns, designers tend to encode their knowledge about design into the designed artifacts. Christopher Alexander's 'Pattern Language' is one of the few examples where a designer engages in the process of decomposing design into its building blocks, chunks that compose a larger system from smaller subsystems. Alexander recognized that all architecture is composed of certain archetypical patterns. He sought to develop a shared language to facilitate architectural design in much the same way words give the poet means to form poetic structure. (Alexander, et al. 1977)

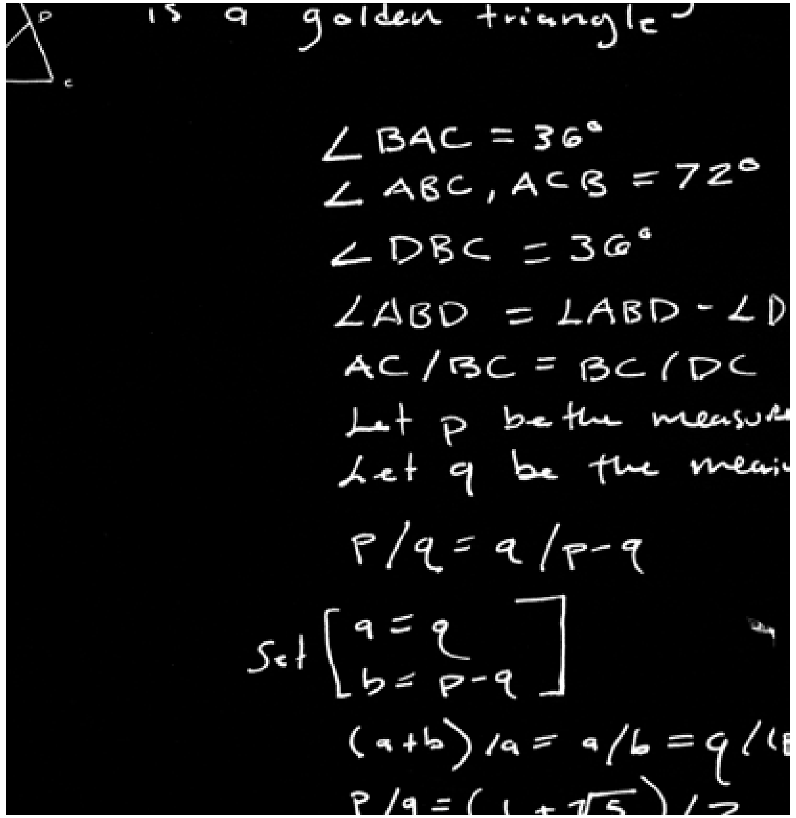
Sketching, the language of design

Aside from Alexander's pattern language of architecture, sketching is the closest thing designers have to an abstract language. Through sketching, designers quickly represent the pieces of a problem and begin testing potential relational structures. For instance, when industrial designers and architects sketch, their drawings relate directly to the physicality of the object they are envisioning. Each sketch is both hypotheses and experiment. Sketching gives ideas physicality and record. Giving an idea spatial form affords the external world access to the design while it is still pliable. It can be shown to fabrication experts for feasibility evaluation and to stakeholders to ensure support.

Collective Sketching

Essentially, we need methods for "collective sketching". Sketches start vague and progress iteratively towards precision and complexity. In interaction design, this is known as rapid prototyping where designers engage in an iterative design and refine process that progress from rough mock-ups to tighter working prototypes that emulate the final design. Now consider a system wide sketch of not only the final design, but of the design process; where not





Math and sketching are both methods for representing a problem and giving it physicality only the artifact develops from rough to precise, but where the process and its relational phases are built and defined as the project progresses. Each set of experts are given freedom to innovate, but the externalization of their innovation allows coordination to occur. Therefore, their innovations can actually shape the entire creative process, instead of breaking it.

This idea approaches what Charles Jencks calls "the edge of chaos". To paraphrase, the edge of chaos is that point where a more than usual level of imagination meets a more than usual degree of order. (Jencks, 1995) Order prevents madness from destroying project purpose while madness allows leaps of insight otherwise prevented by overly rigid order. Only through the controlled application of creativity, and a shared language of problem representation, can large wicked problems be specified.

Object Oriented design

What form should the collective sketch take? In programming, this idea of collective sketching is called object oriented programming. Essentially, object oriented programming is the isolation of sub-system function from the operation of the larger system. In this way, when developers are designing interactive systems, they can outline the entire structure in terms of desired functionality. This allows the whole to be understood at a glance. This concept of decomposing larger systems into sub-systems is a fundamental approach for studying and controlling systems and has been outlined for design in Alexander's *Notes on the Synthesis of Form* (1964), based on Ashby's *Design for a Brain* (1960). These days it is known as pattern-based design. As programmers begin to build the "guts" of the program, they are given liberty to accomplish the desired sub-function in whatever way meets the connection points of the system. Because the pieces are modular, the entire system can remain flexible and adaptable to shifting requirements. Most importantly, this flexibility allows for innovation, to occur in any of its pieces.

By organizing complex routines into distinct activities, the programming work may be divided between multiple individuals. Each modular piece needs two things. First a functional purpose. Second, protocols for interfacing with the whole. The term interface here indicates the connection points with the larger system. The efforts of multiple individuals can be focused while maintaining relevance to the larger structure. Furthermore, the surgical difficulty associated with future maintenance and improvement is less disruptive. Contrast this idea with non-modular systems, where every individual must be given prolific specification concerning exactly what they should produce so their work does not destroy the system. However, by isolating functionality into self-contained modular units, modifications remain internal and do not disrupt the movements of the larger structure.

Think of a bus. A bus moves people from point A to point B. It contains everything necessary to accomplish this purpose. This is its functional purpose. Its interface is every point at which it contacts the larger system. For example, its wheels are designed to move along pavement; its signs are designed to be legible to those at the bus stop; these are its interface points. However whether the bus contains an internal combustion motor or is propelled through nuclear reaction is immaterial to the larger system because such details do not effect the systemic function of the bus (moving people from point A to point B).

Whenever changes to one sub-system affect the interface with another sub-system, change can be made through mutual agreement between the two systems. Suppose hovering became feasible for busses. The interface between the city and the bus (the road) would need to be examined to ensure that this change in the interface did not disrupt the internal operation of the city. Therefore, interfaces that are specific and simple are preferred to those that are vague and complex.

This modularity of purpose allows designers to describe the bus in terms of its functionality and avoid dealing with the mechanics of how it accomplishes its function. By avoiding these details, planning a city-wide bus route is made possible. Imagine if the planners were forced to design a city-wide transportation system from the complexity perspective of the engine's individual parts. They could no longer say, "the bus will arrive at 45th at 5:00 and proceed to 12th". Instead, even the most basic actions would require complex mechanical explanations. The complexity of the pieces would obscure the larger design.

Conclusion

Where do we go from here? Essentially, large problem resolution is only feasible through decomposition into modular patterns. For systemic coordination to occur, creative teams need shared protocols and common terms for painting the big picture without obscuring the nature of the pieces. A natural first step would be the identification of patterns common to complex problems in much the same way Alexander has identified common architectural patterns.

Developing models to represent the connection points between the design phases will smooth phase transition. Perhaps this could be done with representations that allow teams to define the problem and give it structure as the problem unfolds, since in a sense, the model of the design process becomes a map to the solution space.

Part Two: Design as Assemblage

What is design? A plan for arranging elements in such a way as to best accomplish a particular purpose. The details are not the details, they make the design.

Charles Eames

The White Spots in the Map of Design Ideation

To paraphrase Herbert Simon, Design is to turn existing solutions into desirable ones (Simon 1989). The purpose of design is to fulfill needs that are unsatisfactory, or poorly addressed. Design always operates on the assumption that current provisions for addressing needs are in some way deficient. Therefore, the object of design is to create new provisions which will meet these needs more effectively. Yet, how does one create that which does not yet exist? The idea of guaranteeing the production of something that is yet unknown seems paradoxical. Incredibly, designers confidently set out to produce innovation without any pre-assurance of success. This begs the question, does the designer's confidence in their creative abilities exist due to a knowable / repeatable process and if so, what is this process?

What makes 'matter' complex:

We know that designers are engaged in the development of new things. Looking closer at the nature of "things" tells us something about how they can be conceived. First, the Law of Conservation of Matter and Energy states that "matter cannot be created nor destroyed but can change its form." New matter cannot spring forth from the void, just as existing matter cannot vanish. In other words, the total weight of the universe is constant, and every apparent creation or destruction is in reality a transformation.

All matter is divisible into progressively more basic structures. For instance, a glass of water is the collection of water molecules. Every water molecule can be broken into two hydrogen atoms and one oxygen atom. Every atom is the express structural organization of a specific number of protons, neutrons, and electrons. Amazingly, every instance of the infinite varieties of matter can be decomposed into these three elemental ingredients. Note that as we move up in complexity from these base ingredients to something more complicated (like a water molecule) that the pieces (hydrogen, oxygen, protons, neutrons, electrons, etc) although remaining intact, are swallowed up into the identity of the more complex structure.

What bearing does the nested nature of matter have on designing? Remember that design is itself an act of building structures, Design artifacts and ideas cannot develop from the nothing any more than matter can. Designed forms are always the combinatory or transformative result of existing forms and ideas. This may seem like a trivial point, but understanding that the stuff designed objects are composed of exist external from the designer, changes the entire way the design process is approached. There is rarely any idea that is fundamentally and altogether novel without having any precedent. (Jones, 1992)

Ingredients:

4.25 in^3 air
0.003 ml water
0.002 ml glycerine
0.002 ml soap

Contrary to this observation, Design is often seen as the fabrication of ideas and forms from within. The designer as a magician is a myth that is rooted so deeply in our psyche that even designers often believe in their mystical ability to produce "Creatio Ex Nihilo" (creation out of nothing). Yet when the designer abandons their internal crystal ball and begins looking deeply into the external problem space they discover the pieces themselves are rich with formative potential.

System boundaries

In order to design, the problems space must be defined. The problem space is the delineation drawn around everything having any relevance to the problem. Delineating the problem space is to isolate that which is relevant from everything else *(See diagram on page 21)*. For instance, if the designer is given the task of producing a logo for an orange farm, the problem space can be understood as the comprehensive collection of every object and idea associated with growing oranges. Of course, some pieces will be more relevant than others. Once the problem space is identified, further deconstruction splits the elements into increasingly basic sub-structures. All things can be recursively deconstructed into smaller units. For instance, the human body is an independent entity composed of sub systems such as the heart, lungs and brain. Remove any of these sub-systems or modify their relationship, and the resulting structure is no longer a human body. The noun "body" is an invention used to describe the structure of these sub-entities when they are in a very specific relationship with each other. Each element within the prob-

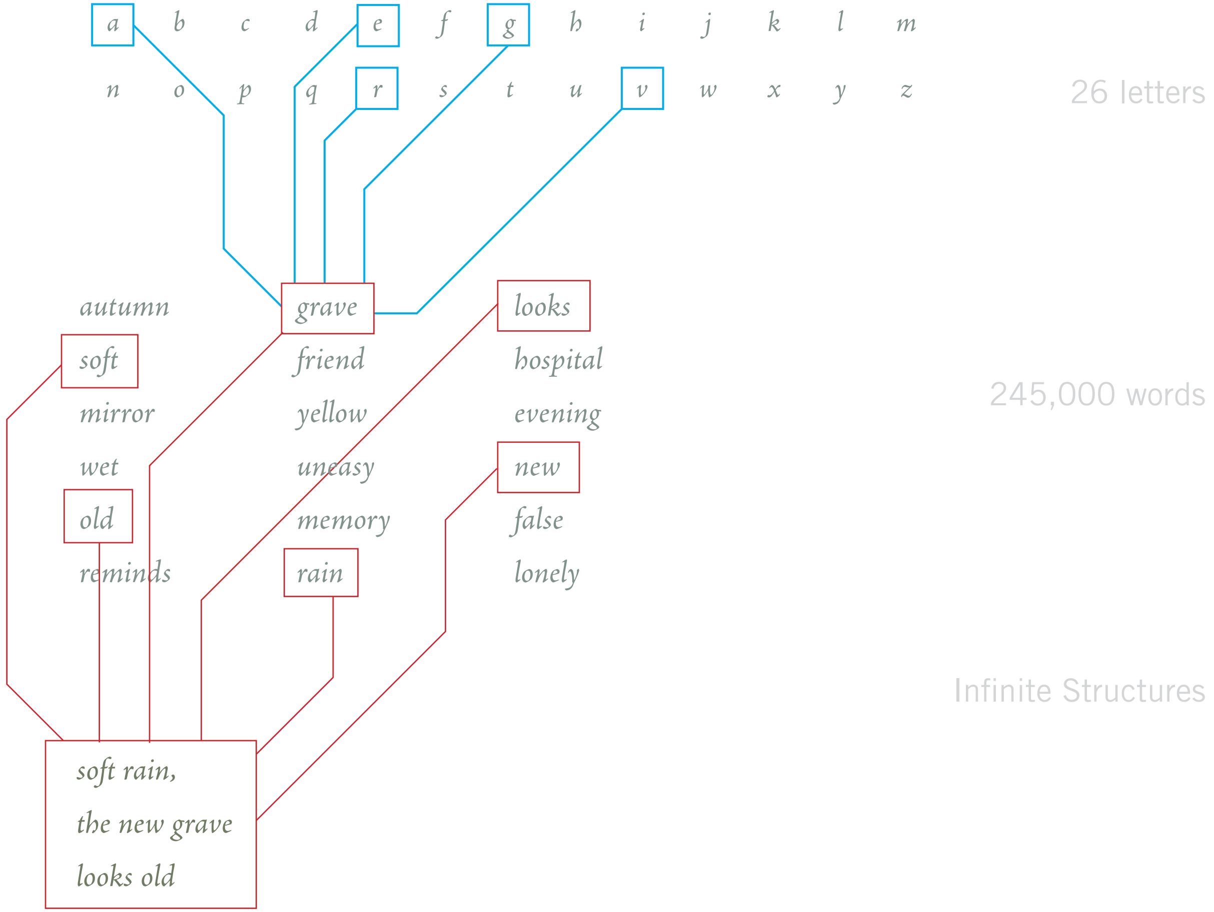
The first formative step in the design process is the identification of the relevant pieces.

Design is more than finding the right ingredients, design is composing the pieces with careful elegance.

Whether a skyscraper, a chair, or a poem, all designed things are structures composed of smaller units. The challenge is in the organization of the pieces.

lem has unique attributes, connections and implications, and therefore, already contain a degree of meaning and unique evocation. Designing always involves the blending of these meaning-laden pieces. Therefore, one of the first steps in the design process is the delineation of the problem space and the identification of the most important pieces.

These pieces become the ingredients wherewith the final design will be built. For instance, the most elemental building block of any song is the single note. The musician has exactly a palette of 12 notes to choose from (the chromatic scale: a, a#, b, c, c#, d, d#, e, f, f#, g, g#). The combination of these notes into multi-note structures known as chords allows emotive expression beyond what is possible by the playing of any single note in isolation. There are in fact 1200 possible chord combinations per octave, each unique in its evocation. The combination of chords into a linear temporal structure affords even greater expression. Note, the limited number of notes and chords do not prevent the musician from creating innovative musical structures. The brilliance of music is not in which pieces are used per se, but how those pieces are arranged. The best musicians understand the nature of the pieces so well that they can weave them into original structures

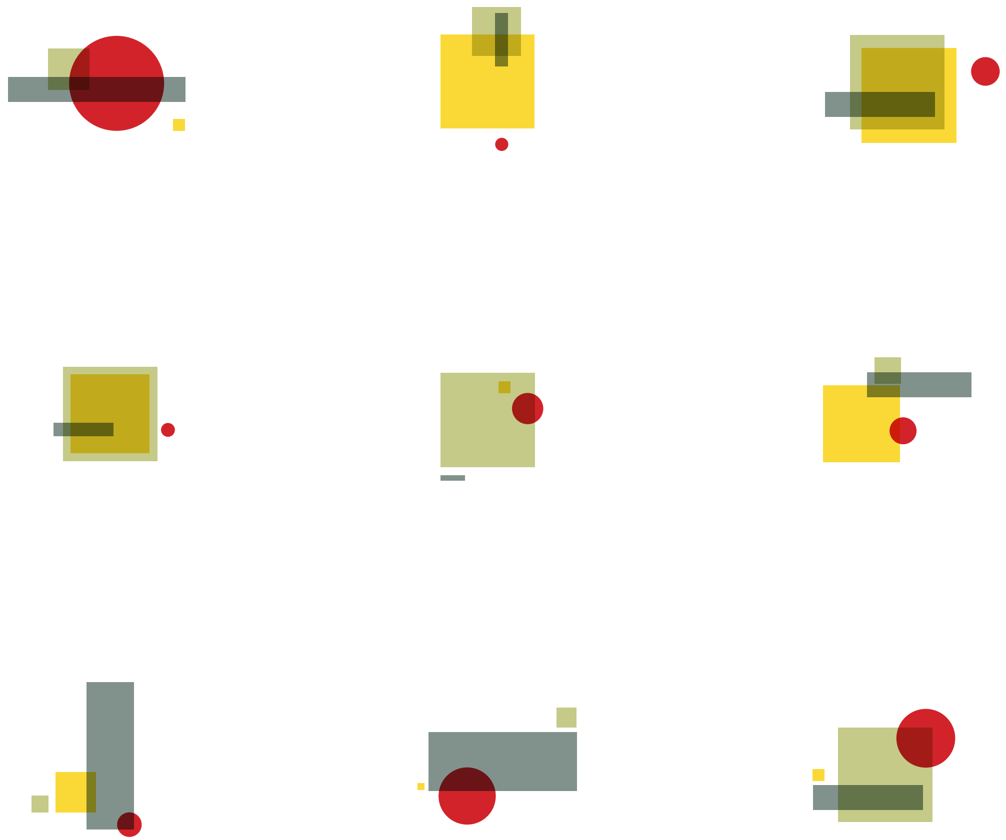


that become whole in their own meaning. The chords and notes disappear into the fabric of the composition. As the composition's complexity grows, the more specific, rich, and complex it becomes. This complexity increases the organizational challenge of "piece" synthesis. Each ingredients of a final design, no matter how small, effects the whole. One has only to hear a performance wherein an unintentional note is played to understand the degree to which the pieces define the whole.

Therefore, generating design is not pulling a rabbit from a hat. Innovation is finding the right pieces, identifying interesting connections and constructing hierarchal structures to illuminate these connections. The designer is a builder of structures, not a mystical creator.

Does this mean that the designer as an individual is irrelevant to the design process? Or in other words that the pieces of the design dictate the ways they should be assembled. Should the form be completely dictated by the problem space with the designer assiduously preventing personal expression from entering the design? Or is the designer an artist bringing richness to the work by investing personal ideas and expression. While finding the right pieces constitutes a necessary portion of innovation, the pieces will not compose themselves. Out of the millions who speak English, there are relatively few poets. Elegant structures are the product of practiced skill and not a little talent.

Even though each of the structures on the opposite page is composed from the same four shapes, there is great variation in hierarchy and evocation.



Innovation and Creativity

Having described the innovation process in terms of organization and structure building, we are ready to ask the more difficult question inherent in innovation: Where do novel ideas and structures come from? In light of our musical example, the question could be posed: how does the musician know which notes and chords to use and how should they be composed? This sticky question is at the very heart of design.

In fact this step is probably the most important and least understood aspect of the design process. We know originality is essential to innovative design, but we can describe it in only the vaguest terms. It is sometimes referred to as the creative leap (Archer 1965), the voila or EUREKA! moment. It is the moment of brilliance when the designer conceives of that which has never before existed. It is the instant the brain reaches a critical mass of indoctrination and a burst of formative magic results in the invention of original structures. Note again that the elements of these new structures are not unique, but their organization and implications are original and often radical.

However, describing how creativity occurs proves very difficult. We recognize it when it happens, and we know the things that seem to trigger it, but the actual mechanics of innovation are rather hazy. Incredibly, in many individuals this lack of mechanical understanding does not stop them from repeated innovation. As strange as this sounds, similar scenarios are not uncommon. I can't tell you how my microwave works, but that doesn't stop me from popping popcorn. This lack of functional understanding seems to indicate the existence of a subconscious genius accessible only during lucid moments. Is the act of innovation simply creating an environment where these unconscious powers of formative brilliance can bubble to the surface?

Because creativity is repeatable, then one should be able to represent it–which in turn infers that it can be understandable at some level. An understanding of the mechanics of innovation is at the very heart of identifying ways to accomplish design more effectively. Therefore, when presented with a design scenario, how can we lay hands on this ability to generate true novel solutions? A tradition of mystification of creativity prevails through the history of innovation, as we have noted earlier. Picasso purports the detrimental effect of the conscious explaining, “the enemy of creativity is good sense.” But since we have established that artifacts are in reality the composition of existing forms and ideas, the difficulty of originating form can be broken down into the for questions:

1 What is the purpose of the design? I.e.: What end does it hope to achieve?

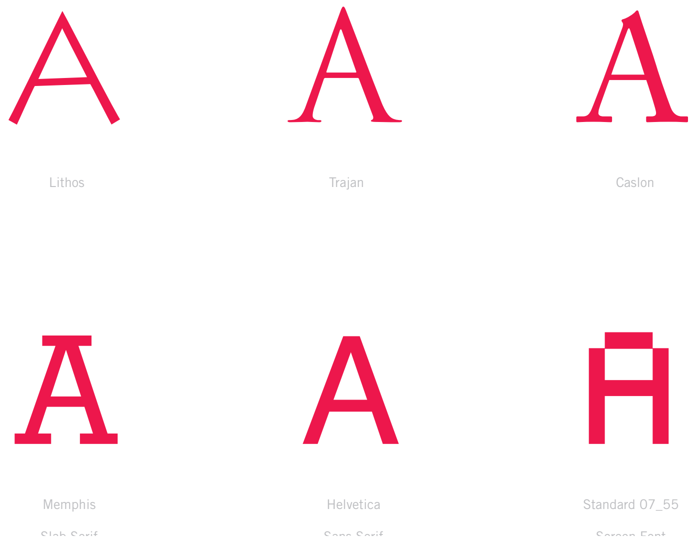
2 Which pieces of the problem space are relevant to this end?

3 How should these pieces be composed to achieve the design purpose?

This illustrates that perhaps some ‘good sense’ can inform design reasoning. Essentially, designers know there is potential for innovative form in every problem, but identifying where that potential lies is another matter. David Perkins provides an excellent analogy for this dilemma. Speaking of the Klondike gold rush of 1897, he explains, “The difficulty is that gold is where one finds it. The prospector know what gold looks like, but cannot track gold down because gold does not leave tracks... The prospector has to spend a great deal of time casting about.“ (Perkins & Simonton 2003).

Although any design can be analyzed and deconstructed to reveal its substructure, composing such structures without the benefit of hindsight proves more challenging. The purpose of this section is to demonstrate how all things are composed of substructures, and that design is the process of identifying the relevant ingredients and composing them into new structures. Although an exhaustive look at how to accomplish this innovation is beyond this work, the following represents an cursory look at a the seven following analogs in an attempt to shed light on the moment of innovation:

1- Evolution: Innovation through small steps
2- Farce: Innovation through nonsense
3- Alchemy: Innovation by stubbornness
4- Rebellion: Innovation through rejection
5- Archaeology: Innovation by adding the twist
6- Math: Innovation through formula
7- Voodoo: Innovation through ritual



The evolution of letterforms can be seen as the gradual adaption of traditional forms to new needs and ideas

Evolution: Innovation through small steps

Evolution of existing form is probably the most common way things are designed. Alexander describes this as the unselfconscious process. Unselfconscious design occurs without designers in the modern sense of the word. Form is gradually improved whenever one of its parts fits poorly into the form's overall context. These changes are brought about not by a designer, but by the people who build and use the form. Its identifying characteristics are:

1 "There is no deliberation between the recognition of failure and reaction to it"

2 There is often little understanding of the "why", only the "how" (Alexander 1964)

Though the unselfconscious process relates primarily to primitive cultures, something similar occurs in the contemporary world with a few important differences. Whenever a stable form is subjected to the instability of rapidly changing culture, it must be evolved if it is to remain viable or applicable. Evolution is driven by the ability to adapt to a changing environment. In the case of human adaptation, this adaptation might initiate changes in the environment, or the changing environment that necessitates adaptation is the consequence of prior design activity.

For instance, the alphabet is a set of abstract symbols which represent audible sounds. Although their basic form has remained relatively constant through the centuries, the alphabet's form has evolved to meet the shifting requirements of legibility, technology, and aesthetics. Designers change the physical form of the letter in specific ways to cope with new requirements. Innovation through evolution is very much a survival of the fittest mutations. Changes that improve the function of the form will be preserved. Those that hurt this relationship are discarded.

Many of these mutations are driven by changes in technology. Serifs were added to letterforms as a way of terminating the chisel blow when carved in marble. However, a side effect of the serif is improved legibility. Serifs ease reading by providing a transition from one letter to the next. Therefore, serifs remain on letterforms even when there is no need to terminate the top and bottom of the chisel blow. Recent changes in letter forms can be traced to the development of the desktop computer and the need for legible screen fonts. Such fonts became vogue even in print applications during this time.

Innovation through evolution makes small modifications until the form works better than its previous iteration. It is slowly adapted and improved. Interestingly most of our enduring forms probably developed in this way.
(Peaked roofs, forks, shovels, gloves, pants, etc).

Alchemy: Innovation by stubbornness
Alchemy is step between magic and science. It is in a sense, stubborn experimentation in a sphere where there is relatively little known about the problem space. Therefore, innovation through alchemy relies on a heavy dose of curiosity coupled with serendipitous experimentation. In this sense, the designer has an advantage by not being an expert. He can try things out of ignorance that informed specialists would never do. Much like an amateur tinkerer in his garage trying new things for the sheer pleasure of experimentation, the alchemist designer freely mixes styles, ideas, and methods to make design gold.

Rebellion: Innovation through rejection
Designers place a strong emphasis on originality. No designer is more universally despised than the hack (the individual who merely applies existing stylistic facades to their work). With this driving undercurrent of originality, new forms are often created simply by doing the exact opposite of whatever currently exists. The benefit of rejecting current work is an assurance that the design will be breaking new ground. On the other hand, design can fall prey to a malady rampant in contemporary art; difference for the sake of being different.

Most revolutionary art does break with convention, but truly revolutionary art not only revolts against something, but offers something in return. Its implications change the very way we think. Inferior artists often mimic revolutionary art by revolting for the sake of revolution. This kind of work lacks substance. Therefore, although their work smacks of great art, it denies the power thereof.

Formulaic revolution is hollow. Is the work different because it espouses new ideas, or because it simply zigs when convention zags? Reactionary revolution is defined by the very ideas it claims to reject. Blind revolution produces more heat than light. Nevertheless, a healthy streak of nonconformism opens the door of innovation through new looking.

It can be refreshing to abandon all pretense of propriety and explore ideas that are wholly inappropriate for the needs of a project. Doing so allows the designer to go places the mind tells him are not right. Breaking down these hesitancies often lead to brilliant and unexpected solutions. The line between madness and genius is often a thin one.

Farce: Innovation through nonsense
What happens when we pretend there are no rules, that all rules, no matter how contrary, can be combined with another. -or- we purposefully do that which is opposite to our aims to achieve them from behind. This can be seen in the work of post modernists such as the Memphis Group architects and David Carson (who once set the text of an entire magazine article in ding-bats). It is also evident in the work of Marcel Duchamp and the Dadaists. Farce elevates the absurd, and in the process creates original structures. Sometimes a brief foray into the absurd can bring new life and innovation to even the most serious of projects. Questioning the boundaries of propriety can lead to ideas otherwise un-considered.

Archaeology: Innovation by adding the twist
Archaeology is the science of recovering lost culture. The archeologist carefully studies the evidence found in the earth to construct stories of people who can no longer tell their own tales. Ethnography, the study of cultural and individual behavior, is finding greater application to design problems. Like the archaeologist, designers can stop fabricating stories, and begin uncovering the fascinating material beneath the superficial cultural surface.

In this sense, the designer seeks to capture the essence of the unique qualities already embedded within the problem space. For instance, the British architect Charles Jencks became fascinated with the chaotic population cycles of Scottish rabbits. When commissioned to design a piece of furniture for a Scottish client, he constructed the entire piece with the aim to give this algorithmic relationship physical form. By doing so, the pieces of the problem space were organized in an unique innovative way. Simply applying a stylistic treatment rather than developing a unique concept from the problem space would probably have led to something more conventional and lacking dynamism (Jencks, 1995)

Math: Innovation through formula

Math is essentially content agnostic since it can operate upon diverse situations and objects. A formula is a specific sequencing of a relational set of values. The beauty of a formula lies in this agnostic view of its values. Thus the Pythagorean theorem is as useful for measuring the height of a skyscraper as it is for determining the correct trajectory of the space shuttle.

Alexander describes the codification of design principles, "... the teacher invents teachable rules within which he accommodates as much of his unconscious training as he can – a set of shorthand principles. [...] So that people will be able to make innovations and modifications as required, ideas about how and why things get their shape must be introduced." (1964)

Although designers tend to shy away from anything that smells of formula as an affront to their artistry, rules can be used intelligently and purposefully. These rules tend to apply more readily to the organization of form than the organization of cognitive elements.

The grid is at the heart of the automation of spatial form. By modulating the space between elements, and unifying their relative position along the x and y axis, any design gains a certain degree of cohesion. Experience has shown that certain proportions are more aesthetically pleasing than others. Much has been said about the golden mean and its recurrence in the natural and artificial worlds (Elam 2001). Beautiful proportions are in a sense formulas for aesthetic pleasure.

Design rules are, as Alexander indicated (1964), our best attempt to encapsulate the reason why something works. However they are at best crude mechanical approximations. For instance, when the designer uses the principle of asymmetry, there is no guarantee that they have achieved aesthetic success (or as Alexander (1976) describes this state, "the Quality that Cannot be Named"). Therefore, design rules should be applied with a proper perspective. They are an end to a means, and not a means in themselves. Bringhurst (1992) gave formulaic design proper perspective explaining, "By all means break the rules, and break them beautifully, deliberately and well. That is one of the ends for which they exist." At all times, the designer must hold their search for innovation above the mechanics of how to get there.

Voodoo: Innovation through ritual

"What we do during our working lives is a succession of tricks pulled from a bag filled with stuff of our own mixed willy nilly with that we've borrowed from others' and that we grab out gambits and gimmicks based on whatever is hot, or not, at the moment." (Stermer 1992) Design as Voodoo is certainly a 'far out there' concept, However, it might best match all characteristics that we attribute to a mystification of design – which is, of course, problematic if we approach a systematic capture of design as an activity that can be captured by design methods. The esoteric practices that describe design as Voodoo are:

1 Superstition. Because the act of innovation is not understood, designers sometimes associate rituals (such as listening to a particular music, or sitting in a certain chair) with the act of innovation. There is a potentially apocryphal story that Mozart would have cold water poured over his hands before he composed to stimulate creative production.

2 Fear of destroying creativity through analysis. Designers sometimes are afraid that too hard of a look at innovation will uncover the professor acting as the Great Wizard of Oz behind the curtain and destroy the fragile (un-understood) fountain of their creativity. This fear probably originates in the realization that contrary to the projected image, designers possess no magical ability. Such fear leads to greater effort to solidify the myth of designer as mystical savant.

3 Innovation through voodoo is hit and miss because it is not understood.

4 Chalks up success to innate unknowable indefinable talent.

5 Such designers are terrified that will never have another good idea because they don't understand how they "found" previous success.

6 Finally, design by voodoo is steeped in ritual and worship of design idols and superstars. Therefore, much time spent in the award publications.

Parting Thoughts & Bibliography

When I am working on a problem I never think about beauty. I only think about how to solve the problem. But when I have finished, if the solution is not beautiful, I know it is wrong.

Buckminster Fuller.

I began this process with the desire to present visual communication design from a structured, almost scientific perspective. Being familiar with the literature of graphic design, I knew there was room for such a work to be done. However, almost immediately I was pointed in the direction of a group of architects and industrial designers who had undertaken much the same task in the 1960s. I found their work to be extremely important and relevant. Therefore, the writings of Christopher Alexander, J. Chris Jones, Bruce Archer and Herbert Simon became my primary text throughout this process. My initial reaction to reading their work was one of surprise that such valuable ideas were not to be found anywhere on the mainstream Graphic Design horizon, and I wondered why not. Their work was an effort to provide means for resolving wicked problems such as city planning, building design, and industrial design that required cooperation between multiple specialists. Visual communication Design problems have not belonged to that class of complexity until the recent shift into the interactive domain. In other words, such methods and externalizations of process were essentially unnecessary for visual communication designers for most of the 20th century.

These ideas were revolutionary when they were introduced. But to the chagrin of these founders, successive generations of design methodologists moved the field into an increasingly academic realm, and lost direct connection with the field of practice. These successive generations viewed the early work as somewhat naive and impractical because its ideas about using artificial intelligence to resolve design problems proved problematic. However, this underlying theme of artificial intelligence and computer based problem solving is certainly indicative of contemporary issues, and can potentially obscure the rich ideas beyond. The core ideas presented by these early design methodologists about what design is, and how it can be undertaken couldn't be more valuable.

Unfortunately, these texts can be somewhat inaccessible to visual communication designers because they have been written in a technical language =comfortable in the scientific or engineering field. Therefore, their density can be a stumbling block for many designers. I have tried to present these ideas in a format more accessible to visual designers while avoiding watering them down. These ideas begin to address a whole host of issues that are frustrating contemporary designers.

In some ways, the final form of my thesis became more esoteric that I originally planned. My initial goal was to provide a concise and easily digestible document that communicated the essential nature of design to those unfamiliar with its purposes and practice. Such a document would be valuable in several ways. Such could be used to inform our clients how they should best use our unique talents. It could also have application in design education where students are expected to obtain an increasing degree of technical skill in addition to their core design training. Furthermore, giving form and framework to Design will increase the intelligence of its member's dialogue.

Another area that holds great potential for future examination, is the gaining of a greater understanding of creativity and innovation. This is a unique avenue of research, and there is much about its operation we do not yet understand. Furthermore, this one attribute is probably the most distinct and important quality of the designer, yet we know so little about how it works.

Finally, I have approached this work with a background in programming and development as well as Design. In light of the difficulties that sometimes arise between developer and designers, I hope this paper is a step towards the facilitation of mutual understanding and improved collaboration among these disciplines that so often find their borders blurred. Understanding how each other work and approach the problem solving process will undoubtedly lead to more effective multi-disciplinary teams. To quote George Nelson again, "No design can exist in isolation. It is always related, sometimes in very complex ways, to an entire constellation of influencing situations and attitudes. What we call a good design is one which achieves integrity – that is, unity or wholeness – in balanced relation to its environment. The reason good design is hard to come by is that its creation demands a high degree of emotional and intellectual maturity in the designer, and such people are not found too often."

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Abstract: Designers are prepared with skills in addressing problems that require novel ways of thinking and unconventional approaches. Design problems are usually underspecified or ill-defined problems. Although the process by which designers address the problem space can at times be opaque to developers in complex project settings - and even seem 'intuitive' to the designers, they are very adept at bringing new innovation to a problem. However because their process is less transparent, collaboration with techhnology oriented developers can be challenging for both parties, designer and technologist alike. This Thesis looks at how designers approach and resolve problems from the perspective of a Designer in an effort to better understand and communicate design as a special kind of expertise,an as a means to address design problem spaces. It treats the difficulty of representing design problems as a shared model among development stakeholders with different, yet similar conceptions of design. Finally, it examines the elusive quality of creativity by deconstructing the nature of "things" to better understand designed objects as assembled structures