3 A Dialogue in Design

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Introduction

The mathematician/cybernetician Louis H Kauffman and Ranulph Glanville (cybernetician/designer) take it in turns to write a "column" for the Journal "Cybernetics and Human Knowing".

Over the years, we have enjoyed many conversations. Normally, we begin a conversation but it does not last long enough: other pressures create distractions. After the conference "Cybernetics: Art, Design, Mathematics—A Meta-Disciplinary Conversation", however, when we both took part in the post-conference, we created an opportunity to hold a more protracted conversation which has developed in fits and starts over the course of two years.

This conversation began when Lou was asked for a mathematician's view of what one of the working groups was doing (folding boats out of paper to explore pattern and recursion: for the outcome, see section 2 of this book). We began to talk about whether this was design, or not. Lou wrote a column based on some of these discussions, and we went on from there.

It was an intention of the conference to bring people from different disciplines together, within the welcoming arms of cybernetics, to find areas of agreement (and of disagreement) just as Rosenblueth, Wiener, Bigelow and their colleagues did in the 1940s, developing one of the 2 main investigative strands that became what Wiener named "cybernetics". The post-conference workshop (see the introduction to the book) gave those who stayed to join it the opportunity to reflect on what they had learnt at the main, conversational conference, and to develop it further.

We took the concept of design. Like the other disciplines that form the conference title, design is both a subject in its own right, and a meta-subject: that it, a subject that can comment on, and often bring together, other subjects (mainly by developing analogies between them). The notion of design is generally familiar, and the word is used (mainly in its form as a noun) universally. However, design is a way of acting (which produces design things). Even these differences, between noun and verb, show that the word "design" is understood in the same manner in different contexts.

We were interested to see how a designer and a mathematician use the notion of design, to find similarities and differences. It is interesting that we discussed in this way: until recently, the conversation would have been, we believe, focused on mathematics: what mathematics, or some aspect of it, meant to a mathematician and a designer. As we continue our explorations, however, it seems that we recognise the value and interest of more of these meta-subjects (in spite of great specialisation). It turns out is a pleasure for us to talk together to help develop these meta-subjects.

The text you will find below has been edited to help improve articulation and to remove some of the repetition. But it was a conversation carried out over a protracted time and a long distance using a medium (email) that is not all that conversation friendly. We have left some of the roughness, and accepted the remaining repetition, including occasionally breaking the time sequence by interjecting comments in parts of the conversation long gone! That's the nature of what we were doing, and we see no need to formalise this offering into a conventional paper, or some such. From the start in the post-conference workshop, we were exploring and this is our journey. This book permits all sorts of formats, and so we experimented. Our interest was not only to explore the subject of design within this deeply cybernetic context, but also to explore each other. We hope that these explorations may spark some exploration in the reader, and, thus, you may also become part of this experiment.

Ranulph Glanville and Lou Kauffman

Main Introduction

This paper began as a discussion at the conference the American Society for Cybernetics held at the Curtis R Priem Experimental Media and Performance Arts Centre (EMPAC) at Rensselaer Polytechnic Institute (RPI), Troy, New York, between 29 July and 5 August 2010. The conference theme was "Cybernetics: Art, Design, Mathematics—A Multi-Disciplinary Conversation" (C:ADM). The work presented here began in the post-conference and then lingered and became in part a Virtual Logic column written by Lou Kauffman (2010) for Cybernetics and Human Knowing. The text of the column inspired us to expand and continue the RPI discussion. We begin this account of the discussion with some excerpts from the Virtual Logic column, combined with a few interjections by Ranulph and Lou. We follow on from this text, developing also the concerns we had shared at the post-conference.

The Column

cI. Introduction to the Column

This column is about cybernetics, art, mathematics, design and the square root of two. The square root of two is an irrational number. A number is said to be rational if it can be written in the form P/Q where P and Q are non-zero integers. For example 22/7 is a rational number. If a number cannot be written in this form, it is said to be irrational.

It was a shock to the Pythagoreans (an active school of Greek philosopher/mathematicians around 500BC) to discover that the square root of two is not rational. This was shocking because the square root of two is the diagonal of a square whose sides are of unit length. The square root of two is a natural geometric quantity. The Pythagoreans believed that natural geometric quantities should be rational. They had to relinquish this belief.

I recommend that the reader go directly to Figure 1 of this column where there is a potentially infinite design composed of many right triangles. You can always make another square—outside or inside, by following the procedure already used, using the procedure shown later on. In the potential infinity of this design the form of the design reenters its own indicational space. This design is the subject of the column. By working with this design we shall come to know better both the Pythagorean Theorem and the square root of two.

Our aim is not just to understand these mathematical relationships, but rather to enquire after the intimate relationship of the process of design and

artistic creation in the bringing forth both art and mathematics and to see the fundamental cybernetic pattern of this relationship.

> [*Ranulph remarks:* "I think I have a problem with this. What I see as art and design are, I think different to what you do."
>
> *Lou replies:* Good! I gather from our other conversations that you take design to be synonymous with the making of a distinction.
> I agree with this point of view, but realize that I may have been using the word design in the sense of 'making a design' (like a weaving or a knot) in writing the paper. The largest question for the designer is to find the 'right' distinction. This is also true for the mathematician who hopes to solve a problem or gain an insight]

This article began when the author decided, at the conference C:ADM in the summer of 2010, to have a conversation on design and mathematics with Ranulph Glanville. To fuel the conversation, I looked around the room, and discovered a book "The Importance of Being Ernst"(Glanville and Riegler, 2007) and in that book an article by Ernst von Glasersfeld on thinking about the proof of the Pythagorean Theorem in terms of design. Ernst pointed out how one could so easily see the proof of the Theorem (for equal sides) from the tiling designs that we have illustrated in this paper. And he suggested that the first proofs of the Pythagorean Theorem may have come about in this way. Understanding mathematics through the eyes of design is surely fruitful. (It has to mean understanding mathematics from the point of view of the basic distinctions, which in this case are very geometrical.)

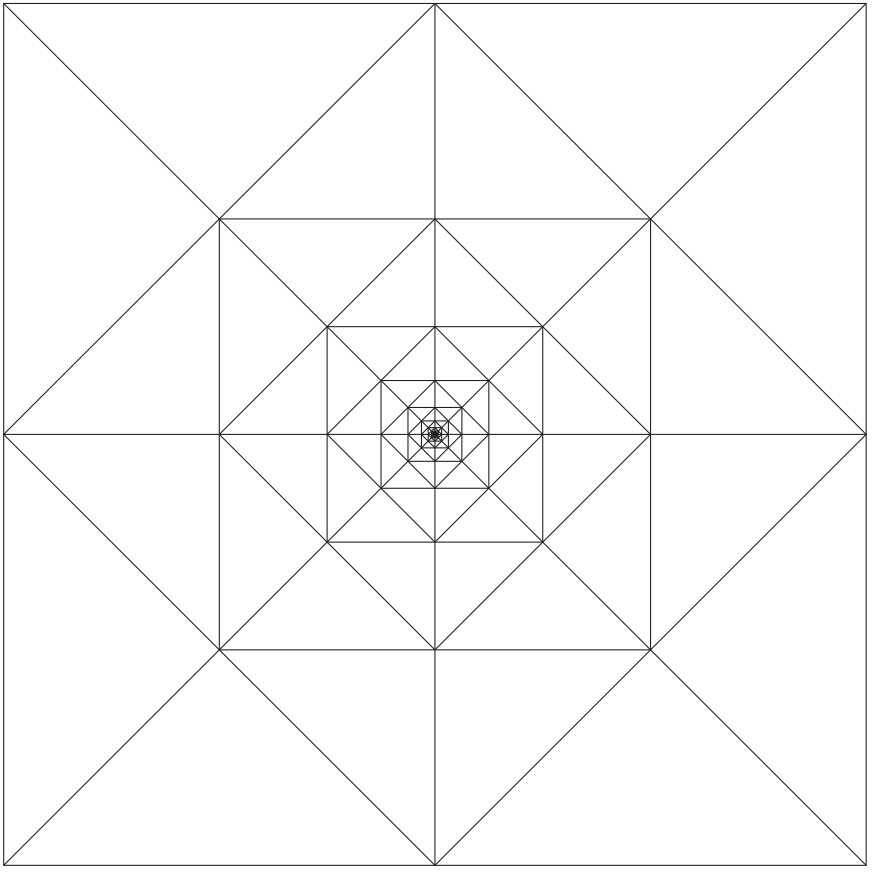
To design mathematics is to bring forth a distinction that makes new mathematics. This tiling design is the seed for new mathematics. Other distinctions create widely different mathematics. Consider the invention of zero or the invention of non-Euclidean geometry. These are distinctions on a large scale.

I decided to play with this, and the notion of iterating the design immediately struck me. I kept looking at that, and the descent in the iteration reminded me of the proof that the square root of two is irrational. Then I realized that the geometry of the descent was exactly what was going on in that proof. So the geometry of this design also motivates the irrationality of the square root of two! However, there is more to tell than this.

Another group, involving Claudia Westermann and Aartje Hulstein (among others) came by while we were working and asked me for mathematical advice about *boats*. I said "I'll try." and came over a bit later to that group. I found out that they were working with folded paper boats, and as soon as they showed how they were folding the paper, I went through the ceiling! For the pattern for making a paper boat is just the same as the pattern for the squares design in the figures in this paper. A design like Figure 1 corresponds to a recursively folded

paper boat, where you make a boat and then fold it further to make a smaller boat and so on to the limits of paper. I invented these recursive boats for the second group exactly because of the relationship of this recursion to the irrationality of the square root of two! There is not room enough here for a discussion of the details of how you make paper boats, but perhaps you would like to reach back into your childhood and remember this. If you do, you will see how you knew that the square root of two is irrational, even though you did not know it then. You can also find something about this in the section that Aartje and Claudia edited in this book (section 2).

FIGURE 3.01. The Infinitely Subdivided Square



cII. The Classical Proof that the Square Root of Two is Irrational

Recall that a number is said to be rational if it is equal to a fraction P/Q where P and Q are non-zero integers. Thus 2/3 is a rational number. Recall also that a rational number may often be put into reduced form where P and Q do not have any common factors. For example

6/8 is not reduced, but since 6 = 2 x 3 and 8 = 2 x 4, we have

6/8 = 3/4. We call 3/4 the reduced form of 6/8.

[*Ranulph comments:* "But not in music!"]

A number is said to be *irrational* if it is not rational. An irrational number cannot be written in the form P/Q for integers P and Q.

To show that a number is not rational, one must show that the assumption that it has the form P/Q leads to a contradiction.

In this section we give an account of the classical proof that the square root of two is irrational. The proof is remarkable for its brevity. We shall assume that the square root of two is a rational number, and derive from this assumption a contradiction.

Theorem. *The square root of two is irrational.*

Proof. Suppose that **Sqrt(2)** is rational. Then we can write

$$\text{Sqrt}(2) = a/b$$

for some positive integers **a** and **b**. *We can assume that this fraction is in reduced form so that* **a** *and* **b** *have no common factor.*

Then $\mathbf{Sqrt(2)\ b = a}$, and squaring both sides, we have $\mathbf{2\ b^2 = a^2}$.

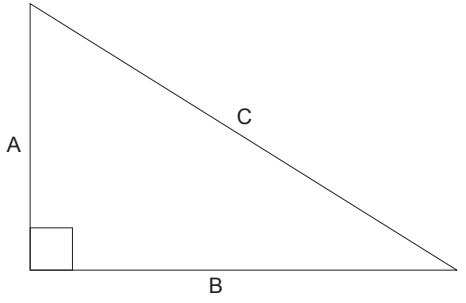
Thus $\mathbf{a^2}$ is an even number. It is simple to verify that the square of an even number is even, and the square of an odd number is odd. Hence we conclude that **a** *is an even number all even numbers are of the form 2 x some other number. Thus all even numbers are divisible by 2*. This means that we can write $\mathbf{a = 2\ a'}$ for some positive integer **a'**.

Since $\mathbf{2\ b^2 = a^2}$ we have $\mathbf{2\ b^2 = (2\ a')^2 = 4\ a'^2}$. Dividing by **2**, we have $\mathbf{b^2 = 2\ a'^2}$. But this means that **b** *is an even number*. We have shown that a and b are both even. This contradicts the fact that **a** and **b** have no common factor. Hence our initial assumption that the square root of two is rational leads to a contradiction. This proves that the square root of two is not rational.

Q.E.D.

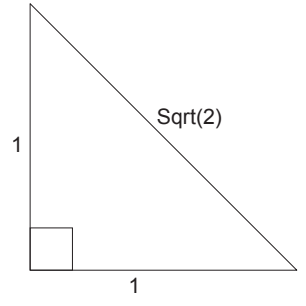
There are a number of issues to examine in thinking about this proof. In geometry the equation $\mathbf{A^2 + B^2 = C^2}$ comes to life in the
Pythagorean Theorem as the relationship between the side lengths
A and **B** of a right triangle and the length of the hypotenuse **C**.
The square on the hypotenuse of a right triangle is equal to the sum of the squares on the two adjacent sides.

FIGURE 3.02. Diagram 1



If $\mathbf{A = B = 1}$, then $\mathbf{C^2 = 1^2 + 1^2 = 1 + 1 = 2}$, and so
$\mathbf{C = Sqrt(2)}$. The hypotenuse of a right triangle with sides of unit length has length the square root of two.

FIGURE 3.03. Diagram 2



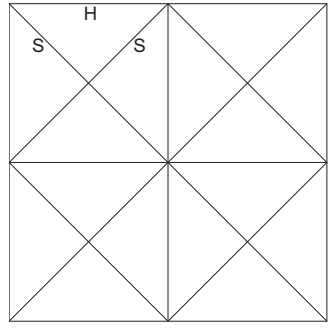
We cannot ignore the square root of two. That number is the first occurrence of a diagonal length in geometry.
How is the irrationality of the square root of two is related to this simple geometry? How does this Pythagorean Theorem come into being? Surely there must be more than meets the eye in a Theorem that engenders the square root of two with such ease. Perhaps this geometric ease is hiding something terrible behind its simple face.

We shall find that the infinite subdivision in the design of Figure 1 is central to both the Pythagorean Theorem and to the contradiction in our proof of the irrationality of the square root of two. Read on.

cIII. The Design of The Nested Squares and Triangles

I advertised at the end of the last section that the design in Figure 1 will tell about both the Pythagorean Theorem and the irrationality of the square root of two. Let's begin by looking at the genesis of the design.

FIGURE 3.04. First Step Design



View Figure 4. In this Figure we have indicated the basic pattern of a simple design that can be made from square tiles, each divided into four right triangles with equal sides. Four such tiles make up the pattern in Figure 4. Concentrate on the triangle with sides H, S and S. This is a right triangle with hypotenuse H. We have H2 = S2 + S2 and so H2 = 2 S2 . Hence Sqrt(2) = H/S.

Now view Figure 5, and think of the design in Figure 4 as obtained by subdividing a single tile with side a. We take a simple subdivision, just dividing the triangle with sides **a, b, b** into halves. A single half has two sides **a' = a/2**, and **b** is now a hypotenuse. Both the triangle with sides **a, b, b** and the triangle with sides **b, a', a'** yield the square root of two as the ratio of hypotenuse to side. We have

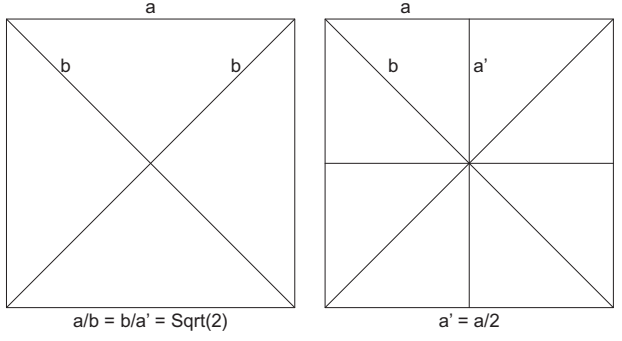
$$\mathbf{Sqrt(2) = a/b = b/a'.}$$

This is a neat rearrangement into a smaller triangle where the roles of hypotenuse and side are interchanged.

In our proof of the irrationality of the square root of two, we supposed that we had positive integers **a** and **b** with $(\mathbf{a/b})^2 = \mathbf{2}$ and deduced that $\mathbf{a^2 = 2b^2}$ and hence that **a** was divisible by **2**. We can think of this argument in terms of the geometry. If the triangle with sides **a, b, b** in Figure 5 has sides that are of integer length, then the fact that **a** is divisible by **2** tells us that **a' = a/2** is also a side of integer length. From this, we know that the triangle in Figure 5 with sides **b, a',**

a' also has all its sides of integer length. But this is a smaller triangle! The whole construction can be repeated starting with the smaller triangle with sides **b, a', a'**. This will beget an even smaller triangle ad infinitum. So if we start with a triangle with integer sides that represents the square root of two, then we can construct ever smaller triangles with integer sides that represent the square root of two. This process *cannot* go on forever because there is a lower limit to the size of an integer, namely the length that corresponds to the number **1**. We have a contradiction that arises in the interaction of the integers and the geometry.
There cannot be a right triangle of integral sides **a, b, b** with a the hypotenuse. This is a geometric proof of the irrationality of the square root of **2** that works in parallel to the classical algebraic proof.
Note that in the proof we have just given, we did not have to assume that the initial fraction was in reduced form. The descent into smaller triangles yielded the contradiction. A similar argument could have been made in the classical proof, citing the fact that no integer except zero is infinitely divisible by the number two.
The infinite descent of smaller triangles exists in the geometry, but not in the integers. Thus arises the incommensurability of the side and diagonal of a square. It is an incommensurablity of the continuous and the discrete.

FIGURE 3.05. The Descent to Smaller Triangles



cIV. Epilogue to the Column

Let's not forget that Plato told us that mathematics must be remembered. This leads to the questions: "What have we forgotten?" "How can we put it all back together?" These are questions common to cybernetics, art, design, and mathematics.

The Conversation—A Dialogue Betweeen Ranulph and Lou

Ranulph to Lou

I think the main thing I have to say is that you use design in a very particular way, and one that has little to do with what those I think of as designers do. I'll write a separate message about this, because I think this can be the beginning of our post-conference workshop piece. But there are a couple of different meanings of design when imported to English, depending on the root disignare and designare. You are using disignare, which is tied up with drawing. So you just mean a drawing, a tile, a whatever, whereas for a designer, thinking designare, the concern is with a way of working. I'll try to explain this when I write again.

I'm interested in your limit to infinite recursiveness. How strange to see something so essentially pragmatic (like the thickness of the rope, in knot tying). What I find interesting is that the proportions remain invariant while the sizes do not. It would, of course, be possible to recurse outwards rather than inwards. Presumably the pragmatics would then have to do with being able to make vast lines?

I'd like to start with some observations on "design". As you doubtless know, design, in English, is both a verb and a noun. When we talk, we tend to talk of it as a noun, as the outcome of some process (design the verb). In your paper, you use the word design—but always as a noun, the result of some activity which might be the activity I call designing. Designers do this, too, and the vast majority of research is into the products of the design process. In fact, there's little research into what designers do, and one reason may be that research, and much that is taken to go with it, are antithetical to designing. Certainly examining the process, a process that leads to the creation of the new, requires, necessarily, research from within: its observer is a second order cybernetic observer.

For designers, the centre of design is designing: the verb which produces the object. And this is what I'm interested in. What designers do when designing, and how they do it, and what this might tell us (for instance, that this is a completely different (to science) way of "facing and dealing with problems"). So I'd like us to talk about doing designing, rather than the outcomes of this process, as I think you might like to talk about doing maths rather than the proofs etc it produces. Of course, the outcomes of both are elegant, beautiful and moving. But I'd like to leave that to the hordes of others!

A word or two about the appearance of design. The oldest form of disciplinary design is architecture, and we have had people doing architecture for thousands of years. (We had designing then, too, but this seems to have been

thought of, correctly, I believe, as normally human and humanly normal. Perhaps this is what we call craft.) However, there was no word for the activity of doing architecture, perhaps because it was thought of as building, and perhaps because drawing was not so easy, technically, as it is now.

The word design came into English in just prior to 1500. It has two roots, according to Eduardo Corte-Real. The first is disignare (which is closer to the sense of design as an activity, as I understand it). The second, is designare (from which we get designate: this is the sort of thing you call design in your column: the tile drawing of the foldings). Architects then took to calling what they did "designing". Designers, per se, were largely a product of the Industrial Revolution. Often designers are playful, they enjoy toying with ideas and love making the new (they are not interested in re-creating the old but in being "creative/original"). They are interested in elegance and beauty. But they are certainly interested in producing the well-made and the fit for purpose. I believe the oldest definition we have concerning design, at least in the West, comes from the year 0 and is due to Vitruvius, who wrote of: firmitas, commoditas et venustas (firmnesse, commodotie, and delight, in the original English translation).

Perhaps I'll go more into the nature of this activity, designing, later. But not in this message.

You may remember that you and I discussed the Pythagoras theorem, and you remarked how easy it was for a 3, 4, 5 triangle, but how other proportions were harder (you use a harder one in your column, but deal with it differently). I suggested it was not so hard, if you put the right triangle on rubber and stretched it. You were, I think, surprised and pleased at this "new demonstration." It was a designer's demonstration, I think. So I'll tell you how it came to my mind. I think of you, before George Spencer Brown and knots, as a topologist. And so I thought, you'd understand a sheet of rubber. So I moved the triangle to a sheet of rubber, and hey presto!

I think this could be an example of designing and mathematicising working together, and I'd love to play with this. If I've noticed anything about how you do maths, it's as play!

I see the point you're making: there's special/general, and there's essentially incomplete. It might be that that helps with design, but I'm not sure of this. To start with, the situation and the description of its elements doesn't happen until the solution is created.

The solution defines the problem, whereas in most formulations we expect the problem to define the solution.

However, this is a defined problem, and what I believe is at the heart of design, which makes it really different from problem solving (though designers have

to deal with problems, too) is that the problem is not defined, and is not a problem. It's not even a wicked problem, though it's closely related. There's the important, even crucial aspect of making the new ideas. This is the conversational bit I talk about) though I don't claim this is the only source of creative behaviour).

So there's a reconceptualisation, finding a clever new way of seeing, that is what happens in your example. And there's the making of something from a sort of scratch, which is what I believe is central to what design offers. To use the word design for the other is to risk reducing our options, and it's this, the way that engineers have "stolen" design and now want to reframe it in their mode, without realising that what design gives us is a different way of conceiving, that most upsets me!

I think this allows us to look at a fundamental difference. You are taking it that the ideas are already there (so you can explore them). You talk of finding some new, of touring a landscape that is there and finding new paths, places that now are revealed as similar and so on.

What I believe is at the heart of design is the attempt to make a landscape. While designers are faced with well-defined problems, and firm ideas with which to play, the heart of their enterprise starts with a great uncertainty of form, of what this will be. It's an activity that involves making form. It also works with messiness, the ill-defined. It's actually a very high risk activity, involving working with the uncertain and the ill-defined, the messy and the unknown.

However, the conversation I am talking about is a conversation the designer holds with him/her self via paper and pencil (I'm writing figuratively). This is the process at the heart of design, the way we create (what we believe is) the new. I'm not so sure if there is experimental evidence to support this but every time I describe this to other designers, they immediately nod in recognition. (There is research on how designers design, but it's very hard to do, and the scale in terms of numbers, generality and duration, is extremely long.)

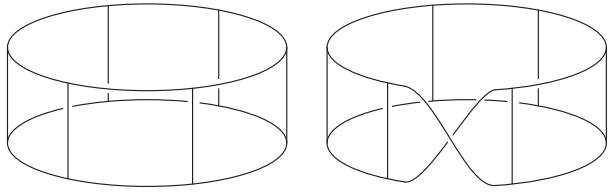
Lou to Ranulph

In order to find a new, clever way of seeing, there probably needs to be an older and established way of seeing. Then the lateral thinking that goes to the new way of seeing can be appreciated and the music between the old and new points of view can lead forward into something more. Good examples are in the transitions from classical physics to relativity and quantum theory.

I also remind you of an image that you have used to indicate the nature of a distinction—as a Moebius strip for the boundary, so that the boundary

becomes permeable through the twist of the Moebius (see the illustration below). This is part and parcel of the design process is it not, as it always allows a new way of seeing and a way-out from absolutes.

FIGURE 3.06.



Ranulph to Lou

I think this is one of the differences we have in understanding. I realise that few ideas are "really" new, and most "new" objects aren't all that new. This reflects the difference between internal and external (my experience may be of the new, even if, in the external account it's not "really" new at all). It's not that the criteria are like Margaret Boden's (2004) psychological and historical novelty: rather it's more of a mind set.

By the way, I see the examples you give from physics, in the manner in which I see the move from First Order Cybernetics to Second Order Cybernetics (although there is an irony that really the original guys were doing Second Order Cybernetics, but Wiener (1948, 1954) published the wrong book first, so that the more technical took those lessons and First Order Cybernetics became the technology and dominated!

Lou to Ranulph

I assume by "the other" you mean equating design with clever problem solving. It is curious that mathematicians, who are certainly theorists and not engineers, do not usually refer to "design". We tend as a community to think that we are exploring the eternal landscape of the Platonic forms, and even if we should manage to create a good design it was already there in the Platonic Land. Thus we use the move that "once discovered always there for eternity prior to discovery". Heh heh ... But nevertheless we do like to think of "0" as a great invention and, say, the congruence notation (a == b (mod p) means p divides a -b) as a great notational design. But those aspects that can be indicated as design or designs are a bit suspect for their particularity.

Ranulph to Lou

For me, design is a way of acting/behaving. This is similar to Ernst von Glasersfeld's "definition" of cybernetics as a way of seeing, not a collection of facts. You like to talk of a design (using it as a noun). For me (and other designers), it's a verb leading to an outcome: usually a noun. I think that for you, design is also pretty much about pattern: hence the tiling arrangements are, in your estimation, design. Not for me!

(Incidentally, the origins of the word design, in English, are 2 (according to Eduardo Corte-Real: designare, and disignare. I mentioned this earlier). When I asked the professor of classics at University College London to translate Man the Pattern Maker into Latin, she came up with Homo Designans.)

As to "the other", you're right in your interpretation.

Lou to Ranulph

Here is something I like to think about. I have long been impressed by the beautiful design of basic mathematics that comes from "Laws of Form" (Spencer Brown 1969). Mathematics seen as directly coming from the making/finding/creating of a distinction. It is understood in Laws of Form that a distinction is inseparable from an actor/observer who is identical with and who makes that distinction.

The mathematics then becomes a play, a story, an exploration of what might come to be if there were such a thing as a distinction. This is quite a different view from the orthodox Platonic view that I have outlined above, but these views are not unrelated! In fact once we get situations with definite rules and procedures, then worlds generated by them do arise almost independent of "us". But the point I want to make is that the initial Laws of Form attitude is very close to the way I conceive design, and I would like your reaction to that.

Ranulph to Lou

I think there is great beauty in Laws of Form. I think the initial insight (instruction) is acute and quite wonderful, and what develops from exploring this is marvellous. The word I like is beauty. There is an astonishing wealth of pattern that is created within this act (for me, I suppose that maths is creating patterns). Remember what the classics prof gave me: homo designans, man the pattern maker. In this case, I think we might both think of the designer as a distinction drawer, redrawing and changing (sometimes by refining). This is an interpretation that is new to me.

I think what you talk about is pattern, and it's this that you call design. This is quite different from my use.

There may be pattern in my sort of design, but I think that becomes apparent in hindsight. Designers are making the new: there is no prediction or predictability for that, and pattern is a way of establishing predictability.

Lou to Ranulph

I would like to continue our discussion to speak about design in relation to distinction. In the making of a distinction one engages in design. For a distinction that is indicated there must be a sign and that sign can be the indication. One often looks for just the right form of indication. One often looks for both the indication and the distinction. But sometimes the breakthrough in mathematics is in finding the right distinction and its indications follows. For example the distinction "Non-Euclidean Geometry" was an enormous breakthrough and it was accompanied by a number of different forms or signs of the new geometries. In fact there are more than one kind of Non-Euclidean Geometry and so the matter of designation for this design is remarkably complex, and it leads to lots of beautiful and palpable representations. When a major distinction occurs in mathematics it often has so many different specific ramifications that the distinction itself looks very abstract and void of a sign. Other major distinctions such as nothing versus something have at once a sign, zero in this case. Can we discuss the nature of sign and design?

Ranulph to Lou

I'd like to write a bit about design and distinction, before we move to signs. Let me start by repeating that for me design is a process. In distinction terms, I am interested in the drawing, rather than the distinction. This places me in a sparsely populated corner of design research. I am not interested (for this discussion) in evaluating the success of a design, nor am I interested in automating how we do design so it becomes more predictable. I regard designing as a very human way of behaving, the way we create concepts (so essential to thinking) and possibly the only real alternative to the way of thinking supposedly practised in science, that we in the west have allowed to continue to exist: so I regard it as important, from a "thought" diversity angle, that we support it.

Designing is not so much about finding the right distinction, as MAKING the right distinction. It is making a point of view, a position, as well as an outcome. And what is important here is that, while we may later look back and rationalize what we did, connecting it to precedents and so on, while doing it we are in a different world, a world of making rather than finding.

There is an approach to design which is entirely the opposite of this: engineering design. I regard it as at best cheeky that the practitioners of this approach have tried to subvert the action of "original" designers to fit their processes and lack of imagination! Their approach is to define (to distinguish) and then to assemble their distinctions in, for instance, a Venn diagram or decision tree structure so as to get the optimal, logical solution to the problem they have defined. My guess is that this approach could be notated rather well using distinction notation. In contrast, in (original) design, we work the opposite way. What the engineers call the solution defines what the engineers call the problem. Designers work with an inversion of a sort of causality, and terms like solution and problem aren't really appropriate.

I maintain that there is not one way of doing design, but that for the act to count as design there must be, at its core, a notion that I characterise (using old media) as a conversation held with oneself through pencil and paper. (I am yet to be convinced that computers do anything but hinder this process, although I have developed some ways of working with computers that I think do add a particular value to the conversation.) The evidence for this position is not experimental, but revelatory: you say this to a designer and they respond with something like "Of course, that's exactly it!". The evidence is in the identification and acclamation of practitioners.

Let me just be a little more precise, here, about what I mean by a conversation. I am going to assume that each of us can take on many roles, and two of them are mark maker (drawer) and mark viewer (viewer). These are alternatives that we switch between: good designers switch from one to the other so fast and fluently that they do not distinguish the process as serial, and, indeed, it may well be or become parallel.

Here's how it goes. As drawer, I make a mark on some paper. The mark may be "intended" as "random" or it may be copied, some sort of prototype, or perhaps mindless. The viewer looks at it, and sees it differently than the drawer. He says "Goodness, I never realized I'd drawn this-or-that." The drawer now responds to this in some way, perhaps highlighting or focusing on this-or-that, perhaps rejecting it, perhaps just drawing some more (apparently untouched).

The process continues in a potentially endless circularity. Gradually, the designer may introduce problems to be dealt with (there are indeed problems, and they are important, but they are, in my opinion, not the core of the act of designing). The outcomes of this process become enriched. We also face a stopping problem, but that is perhaps outside the range of our discussion. (I think we just decide to stop: our criterion is "good enough", not "correct".)

I do not see this as drawing a distinction, I see it as vaguer. For the drawer, it's

often just drawing. The viewer may see it as a distinction, but that is after it is made. I don't know if George Spencer Brown dealt with this: it has always seemed to me that there is a sort of factuality about George Spencer Brown's distinctions. Drawing a DISTINCTION brings things into being. I think I'm talking about DRAWING a distinction, if distinction language is of any relevance at all—and I'm not sure it is.

However, there is another way of thinking about design and distinctions, and this may be more to your taste. Let me talk in a reified world, using reified language, to make this simpler to say (and hear). And let me talk about the designed object (a building, for instance) as existing per se.

Let's think of a building with walls. Let's take it as existing in a real world, for the sake of argument. Looking at it (sensing it) I distinguish the wall. It might be a plain surface, or it might be deeply articulated as in, for instance, gothic cathedrals. I can read each layering of the wall just as I can read each reconfirmation of the wall (each repeated glance) as distinguishing again. In one case I am making the distinction richer and richer: a sort of recursion of enrichment. In the other, I am distinguishing the same distinction, a generator of memory and of "object constancy".

I might then consider a building like a Mayan temple. These building had structurally vastly over-engineered walls: in the Temple of the Inscriptions at Pallenque, they are over a meter thick. The reason I was given for this (by a mathematician who did a guided tour, and it was this insight that turned around architecture and George Spencer Brown for me in 1978) was that the Maya wanted you to realize that as well as in and outside space, there was the space of the wall. I call this zero space, after this Mexican mathematician, who talked of it in terms of the role of zero between the positive and the negative numbers. So here the wall is thick enough to be the mark and the value together as a unity. (The enrichment of the wall is the recursion between mark and value, when they are taken as separate.)

Then we might go to Mies van der Rohe's Barcelona Pavilion (or the reconstruction for the original was knocked down at the end of the Barcelona 1927 world fair). This is a building of endless ambiguity. You can only draw a distinction to ask a question. The reflections of the polished surfaces, the water and the (thick) glass mean that the building needs constant redistinguishing: you have no idea what's where, and it keeps changing. This is not so much a recursion, as a multiplicity of separate observations (distinctions) that we draw, hoping perhaps for some pattern, and leaving us endlessly undecided. (Now you see some of my delight in ambiguity.)

Of course, these comments work in a reified world. But that's a world we often inhabit, not least because it's convenient.

How did the designers make these complex, multi-distinguished walls? Did they have in mind the redrawing of distinctions by observers, or were they only dealing with their own distinguishing, their own processes of postulation and wondering that form the design conversation I have said is at the core of designing? I don't know. What matters for me is that these different views give me different understandings. I do not ask that they fit together but that I can move between them. The consistency I look for (and which I am beginning the think is at the heart of second order cybernetics) is not a consistency of view, but of process pursued from many points of view.

I am not sure how this fits in with what you had in mind. I do know that this is a summary of how I understand distinguishing and designing, and different approaches. Perhaps you can interpret it into your frame in an articulated manner?

You will find some of this stuff in various publications of mine. Recently, there is a Cybernetics and Human Knowing piece "A (Cybernetic) Musing: Architecture of Distinction and the Distinction of Architecture" (Glanville 2010). The column before it was about design. You might also like to look at Glanville (2006) (2007a) and (2007b).

Lou to Ranulph

I will respond to the idea of "making distinctions" in relation to mathematics and also to engineering design. There is much more in your last paragraphs that I could remark upon.

Let's consider some examples. Claude Shannon drew a relationship between Boolean algebra and switching circuits. He drew the relationship that switches and the circuits made from them could be open or closed in analogy to the Boolean 0 or 1. He drew the analogy between switches in series and the logical AND, and the analogy between switches in parallel and the logical OR. He drew an analogy and I deliberately use the word "draw" for this, for Shannon drew or made a distinction that was the joining of the subjects of Boolean algebra and switching circuits (***1*). I suspect that when he did this, he reflected on it just as you or I might after drawing a distinction and saw that there was much in it that he had not at first imagined. The drawing of this initial distinction is the most interesting part from the point of view of design and if one happens to be interested in the subject of the relationship of circuits and what can be done with them, then it opens the possibility for drawing forth this field of relationship. At this point there is the possibility for transition to engineering design since Shannon's original approach has much that is implicit in it that can be made automatic and calculational. I do not want to dwell on that.

The key part is in the drawing of the fundamental distinction/joining that makes a new point of view, a new world. (**2)
Another example is George Spencer Brown's discovery of the role of distinction in the very general sense of knowledge and the creation of form. He started by making a better notation for Boolean calculations for circuits and networks, but in the process discovered that he had invented a notation that itself represented the drawing of a distinction. (**3) The notation and the act of drawing that notation represented forming a distinction from a void, from a place where no distinction had as yet been drawn. He understood that his self arose in the process of drawing that distinction, and he solved the problem of the nature of form in the form of the process of drawing a distinction. It is remarkable to contrast this very self-conscious mathematics with the more reified examples like Shannon's great discovery. Most mathematical discoveries are not accompanied by the degree of awareness that is implicit in Spencer Brown's fundamental turn.
Still, I want to talk about drawing distinctions in mathematics proper and I will give one more example. Euler considered the infinite series
S = 1 + ½ + 1/3 + ¼ + 1/5 + ... and showed
S diverges so that its limit is infinite.
S can be written as the product over all primes p of the quantities 1/(1 – 1/p).
From 1, and 2 Euler concluded that there must be infinitely many prime numbers, for a finite product of numbers is finite and he knows that E is infinite.
By examining the logarithm of E, Euler further showed that the sum of the reciprocals of all the prime numbers also diverges. This was entirely new.
What kind of distinction has Euler drawn? He has done something new, something that had never been done before and he has done it by encoding all the numbers in an infinite expression and then translating one infinite expression to another by using the fact that every integer can be uniquely written as a product of prime numbers. Discoveries of this sort are very rare indeed and they involve all the matters that we have been discussing.
Euler comes to these results through his experimentation in making calculations with series. He becomes the first master of the infinite by making distinctions in infinity that yield tangible and definite results about (all) the finite numbers. He is the first person to actually calculate with the infinite. He has created that possibility and we are no longer the same after that.
The matter of process and reification comes up again and again in these and other examples. As soon as someone makes a distinction, forms a process and discovers something new in it, a "thing" has arisen. We tend to make a big name out of the thing and forget the process that generated it.

Mathematics education and mathematical practice if it is of any use, can lead us back to the process behind the reification and thence to new actions and new worlds. (**4*)

Ranulph to Lou

What you write is interesting, and may also help me explain what I still see as a fundamental difference. It also helps me a great deal with your conception of what a distinction is, and some of the history that gives such cultural value. You talk of a distinction joining (in this message, within the above, I indicate a place in the text where I want to make a comment by an italicised number preceded by a double asterix in brackets, in this first case

(**1*): I will use this convention for all the comments related to the preceding message). In this first case, I wonder how how distinguishing can be analogical? I find this difficult. For me, distinction cleaves.

I think you are using some of the concepts you have developed out of George Spencer Brown, and would like to understand how you have developed them, how they are related, so I better understand your extended use of the term distinction, and your notion of "drawing".

(**2*) You refer to making a new point of view, a new world. Using the distinction concept for a moment, I'd say that in design as I have been writing of it, I, the designer, switch roles between the drawer and the viewer in an ongoing oscillation. This is the crossing of a distinction between the roles. It is also a means by which we move from how we began to where we end. But I prefer to think of this not as distinction drawing, because it's messy and out of focus. I'll come back to this later.

(**3*) This is exactly what I have been writing about. What happens when you draw, sketch, doodle, with the role switch I just mentioned, is that you see new possibilities in the mark you have just made. For instance, a notation suddenly is seen as having possibilities one had not thought of and which extend beyond the intended. I think this might be extended to self-awareness: the distinction drawing I do not only distinguishes whatever, but, in the drawing, distinguishes me. I wrote about this in "The Self and the Other: the Purpose of Distinction" (Glanville 1990).

(**4*) I really like this notion of the origin of thingness, and our tendency to reify everything.

So what's the difference I'm insisting on.

First, I see design as being like wandering, lost, for a long time. It has little precision (in terms of product) , until you get to the end. We are not working in a well-defined world, or even a coming into definition, at least not until we finish.

There seems to me to be a precision in distinguishing (which I like a lot). However, design as I deal with it is messy and imprecise. Design involves remaining undecided, goalless, open.

And a remark.

Above, you make distinctions very particular, far removed from the abstract.

And an afterthought.

I think that distinction drawing has a sort of precision and finality, and a clarity, that are not at all what designers go through. Engineering Design (a Johnny come lately in the field of design), and Design Research/Methods in the 1950's and 60's try to make design more like this: precise, clear, final, producing a unique and logically necessary outcome. The current fashion in architecture, parametric design, is perhaps the contemporary expression of this. It's also true that some forms of design, such as industrial and product design, tend towards engineering: the problems are much simpler and more precisely stateable than are those that architects face. But nevertheless, designers from all streams recognize the account I give of the central act of designing.

Design Research is also concerned with the thingness of outcomes, which is why I find your comments on this so interesting and valuable. Design Research is interested in assessment of this outcome rather than the process. And the assessments it gives don't really help designers: they tell you what's wrong, not how to improve (I guess that's a cybernetic expression).

Lou to Ranulph

Let me take up first the matter of a distinction as a joining.

I mean this in a number of ways. First consider distinction as a cleavage. For example I draw (literally) a circle in the plane, cleaving it into an inside and an outside. I could do this and leave a hole in the plane, as with a scissors and a piece of paper. Or I could draw a curve in the plane and not disturb the plane itself. Consider the plane with a hole in it. Then the hole and the remaining plane are joined to one another. Each determines the other. The hole does not exist without its surrounding plane and the cut plane does not exist without its hole. The distinction that we have created joins the hole and the cut plane. In the same way, the drawn distinction joins its outside and its inside into the whole plane. Each distinction cleaves a space and also joins the contents of the distinction to reform that space or a new space. The case of the cut plane is the most interesting since the hole clearly depends on what it is not. The hole is wholly determined by what it is not.

Then there is the use of the word "drawing". I refer to actually drawing and I notice that drawing takes time; drawing is a relatively continuous operation

and the distinction drawn does not appear all at once, but at some point in the process of drawing, the distinction becomes apparent. I think that this process of drawing is like the unformed nature of the intermediate process of design to which you refer.

I would like to ask you how imprecise and open you feel about a design process. Does it not occur within various definite acts that are available to you? When do you know that you have achieved "something". Or should I say "achieved something"? I am imagining my design process for working on an improvisation on the clarinet.

I may start with a definite tune that we have played. And then I take just a few notes of that tune and open the playing of them outward to other directions making movements and listening to what happens. Maybe I transgress from Klezmer to something like Bach and then find my way back. I discover new paths and hearing them I can discover other paths from them. It goes on and I remember a lot of it and can use that as a base the next time I want to practice this improvisation. I may use these ideas in improvising a performance. I have not so much experience in doing this in performance except for a formal doina that we often play before a given tune. I have longer explorations that I am confident that I could explore before an audience. In doing that I would rest in the confidence that the process can be done in front of others and it is my intent that the process while endowed with aspects of precision should not be determined to the letter, not at all, but could become an exploration and exhibition of that exploration in public. Is this like the ambiguity in design for you? I am working in a large distinction.

For example the distinction could be "the relationship between Bach's 2 Part Invention Number 4 and the Boogich Bulgar". They are different in lots of ways and I can explore it by a simpler distinction of making a single change in key signature (at a key point!) that switches me back and forth from one context to the other. I play back and forth across this boundary and explore/create a relationship between the two pieces/contexts. It is easier to describe this process than it is to describe doing mathematics. But doing mathematics is "just like" that. I am also exploring the switching back and forth between doing music and doing mathematics, and talking about both or either.

Ranulph to Lou

There are very nice points above, and they do, I think, help. I'll get to them, but let me start with a lovely case. I'm not sure what it is a case of, and I'm not trying to use it to illustrate (though it does): I'm interested in it as a moment, and event that is really strange, anarchic and bizarre.

I needed to place a fan in a pane of glass. I took the glass to a glass cutter, who cut me a hole. When he made out the bill, it said:
One hole: £5.00
I love it. £5 to gain a void, a nothing. Cheap at half the price, I say!
Well, now, back to the serious stuff (though what could be more serious than the price of the void, I do not know).
Let me try to address the imprecise/open issue. It is of course very rare that a designer doesn't have to satisfy a client and a functional brief. Further, there are limits provided by laws, material behaviours, assembly processes, etc. There is a generally held view that seems to me quite helpful, that the less of these there are, the more one is involved in art rather than design.
All these constraints (as Glasersfeld would have called them) are contained within the first two parts of design that Vitruvius gave us 2000 years ago: (roughly) functionality and well-madeness. The third part he gave us is delight, and this is much harder to delineate and to provide.
It could be that we can treat all the constraints as problems and solve them, although there is always the fear that another criterion might be found that would render this impossible because there would be no unique intersection of all.
Delight is, as I say, another matter, and while cleverness shows up in function and well-builtness, delight appears, generally, in the "arty" bit.
What I have been writing about is mainly to do with this delight part. It's mostly about how to find a form for the object-to-be. I am not personally interested in research that evaluates designed objects, specially when it does not give us a serious means of improving our performance, nor am I interested in historical and sociological research (I won't try to explain my arguments against these here). This is not to say that I don't understand the possible importance of these factors, or that I don't value them: but they are not my interest. What I like is the activity I insist is at the heart of designing, that makes it different to problem solving, and that is this conversational process I go on about. I recently came across a book title that seems to me to get it: "Growing wings while flying".
You bring up improvisation, and I think your analogy is pretty exact. But I anyhow consider design and composition to be close synonyms. Improvisation can be thought of as realtime composition. All the experiences you have in improvising seem to me to be experiences I have as a designer: and which others tell me about.
So I think we probably have reached an agreement, and I think you know the delight not only in the outcome, but also as I like to emphasise in the very act of designing.

You also talk about the drawing of distinctions in time. The first thing I like is the verb. For too long we have talked in nouns. But I'm not so sure about the sense of time you refer to. Yes, I move the pencil bit by bit, time after time. But I also experience the time as a whole, a unity. I understand the drawing as wholistic, rather than a serial event. I don't think I experience the drawing in time as a sequential act, but as one act, one totality. There's a nice musical connection here, too: Karlheinz Stockhausen composed in "moments" chunks of stuff that happened as a wholistic event almost without sequential elements. (This is not true, Stockhausen was very interested in rhythm and started out as a jazz pianist, but it will do as an abbreviation!).

Finally, and getting back to designing, you ask also about stopping. This is a well known difficulty with wicked problems, and there have been attempts to define a "stopping rule". I prefer to think of the criterion: good enough. While designers can be impossible perfectionists, they also know about good enough. Where you can't have a best solution, the criterion has to become "good enough". How, you then ask, do I know when it's good enough? Recognition based on experience.

Does this help?

Lou to Ranulph

I will begin at the end of your last missive. I suggest that we are good enough here in this discussion on design and in the course of its own time, the discussion has formed into a gesture, a distinction, a making that we can be satisfied with and come to an end, with joy!