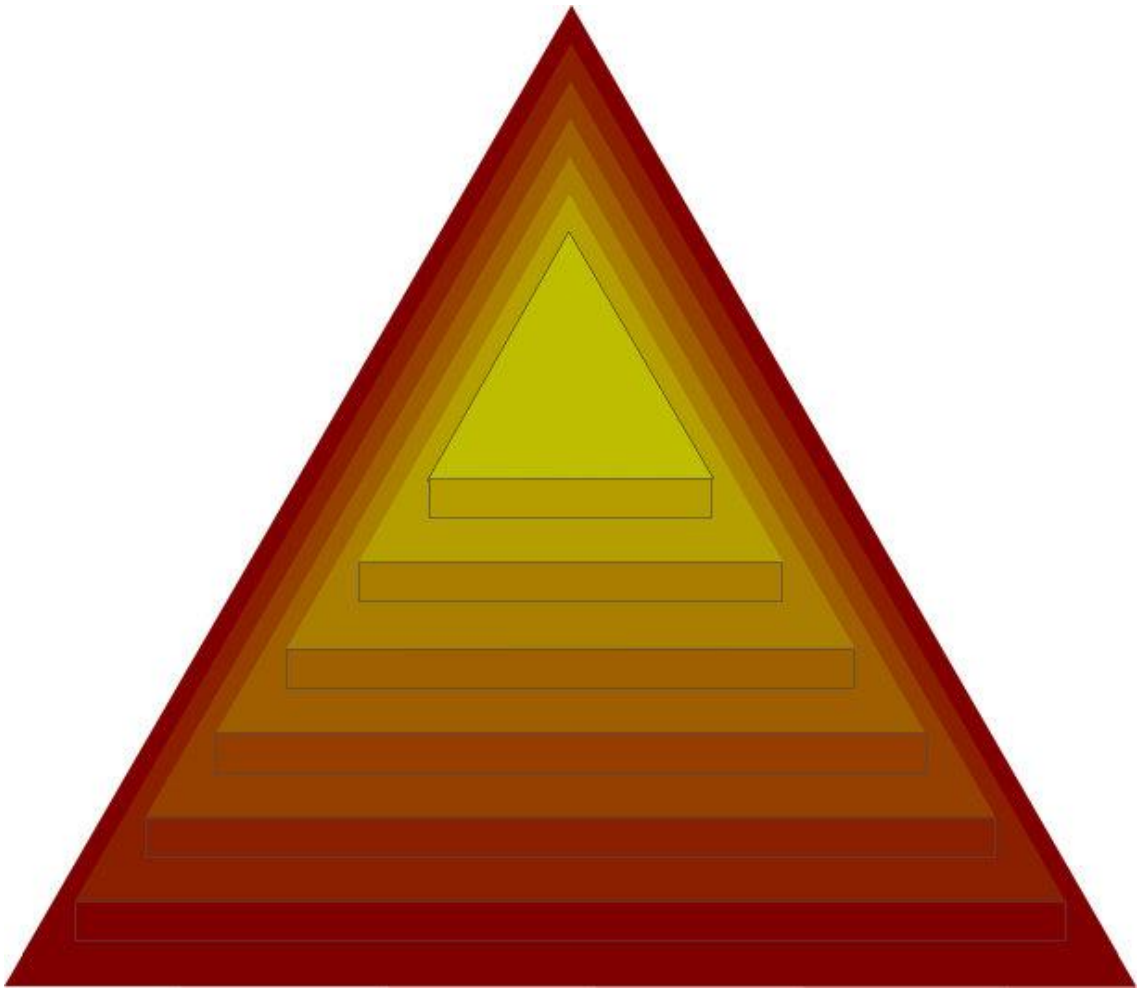
Design

beyond probability



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Content

"De gewoonten der menschen is zodanig, dat zy, zo dikwijls als zy enige gelijkheit tusschen twee dingen bemerken, van beide het geen oordeelen, 't welk zy van een van beide waar hebben bevonden, zelfs hier in, daar in zy verscheiden zijn." [a]

People have the habit, as soon as they recognize any equality between two things, to suppose that equality in everything in which those things differ.

"Er is geen ander zijn dan anders zijn" [b]

There is no other being than being different.

a Descartes(1684)Regulae ad directionem ingenii Regulen van de bestieringe des verstants(Den Haag 1966)Nijhoff
b Bruggen(1924)De grondgedachte van Prometheus(Amsterdam)Maatschappij voor goede en goedkoope lectuur

1. SCIENCE SUPPOSES DESIGN, NOT THE REVERSE

§ 1 DESIGN GOES BEYOND PROBABILITY

Human imagination may construct *probable* pasts and futures as produced by probability-based empirical research, but also *improbable*[a] ones. Some of these are realisable, *possible*. You may *invent* them by *design*, but the required imagination is often blocked by hidden suppositions. This inquiry aims to unmask such blockades.

Some possibilities can be explored by mathematical models extrapolating actual realities as probable by repetition. That may simulate improbable possibilities never observed or imagined before. They are, however, limited to what can be reached by *repetitive* operations. Repetition is the core of mathematics, but not of design.

Exact repetition of *equal* units results in *numbers*. There are, however, different kinds of units, resulting in different kinds of numbers. Their *difference* is usually indicated by the name of variables, expressed in the different characters of algebra.

Operations on numbers such as adding, subtracting, multiplying, dividing, powering, integration or differentiation, suppose repetition as well. Iteration may produce a kind of diversity (eg fractals), but that covers only a part of all possibilities.

The diversity of living nature shows many more possibilities based on *non-exact* reproduction and so does design. In evolution, only *different* genes can produce new combinations. Without any mutation, a combination of equal genes would never have produced the diversity required for the evolutionary survival of some new 'fittest'.

Design does not copy or repete equal things either; it makes something *different*. It may combine old things, but then only the combination may be new.

For an empirical scientist, designers are liars: they draw things that are not true. The modality of design, however, is not *truth*, but a wider concept of *possibility*. What is true must be possible by definition, but the reverse, not everything that is possible is also true. What is true is therefore a subset of what is possible.

That is why I consider any science to be a design, but design not as science only. Science seeks truth, equality, repetition. Design looks for new possibilities, making a *difference* from what is actually true. Science attempts to recognise *equality* and repetition. Only repetition enables to predict and anticipate.

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a Strictly spoken any event has a probablity, but I will use the word 'improbable' as an abbreviation for 'with a very low probability'.

1 SCIENCE SUPPOSES DESIGN, NOT THE REVERSE

Cusanus(1440)[a] already claimed that in reality absolute equality does not exist.
That is why complete accuracy in measuring or constructing is also unattainable.
The exact world of mathematical concepts and relationships therefore cannot be anything else than an *ideal* image of recurring experiences.

All apparent equality amounts to not more than similarity. A creative mind, however, goes beyond repetition, it should distinguish first, before it may compare, summarise and divide.[b] Creation *makes* first of all a *difference*.[c]

Van Leeuwen[d], took equality as the limit of difference, its unattainable zero value.
Something different can always be imagined as more different, but not always as less different. If you no longer can see or imagine less difference, then you may *call* it 'equality', but you still suppose at least two *different* objects in order to compare them and to conclude '*equality*'.

You can count only things that are similar in one way or the other, but you have to be aware that they may differ in other respects.[e]
They at least must differ in location, otherwise they are 'identical', the same thing.

Words generalise repeating truths, probabilities, and causalities.
These are the core of empirical science, but design requires more. What is its surplus?
In order to specify in what sense design outreaches science, I take

1 equality as a special case of difference,
2 truth or probability as a special case of possibility,
3 science as a special case of design,
4 cause as one condition between the many conditions to be fulfilled, and
5 verbal language as a limited reproduction of imagination.

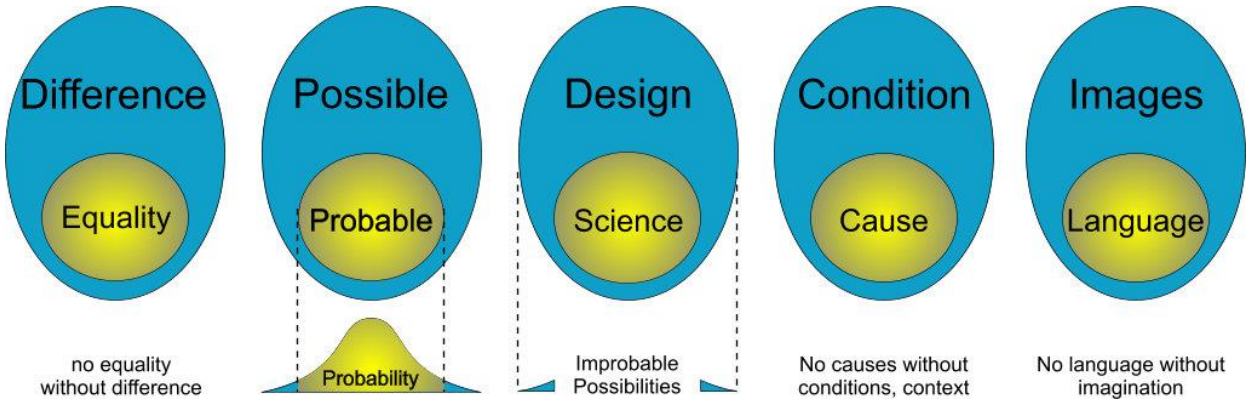

Fig. 1 Primary suppositions

These starting points liberate *design study* from the limitations of *empirical research*.
Science *supposes* design (design *includes* science), not the reverse.

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a Cusanus(1440)De Docta Ignorantia II, 1 p92 https://urts99.uni-trier.de/cusanus/content/fw.php?werk=13&ln=hopkins&hopkins_pg=61
b Cusanus referred by Dijksterhuis(1975)De mechanisering van het wereldbeeld(Amsterdam 1980)Meulenhoff p250
c According to Anaximandros (as early as ca. -575), creation also consisted of separating opposites from the indefinite (apeiron).
d My teacher and predecessor as a professor in ecology the University of technology in Delft.
e The statistical (epidemiological) approach to people in medicine is therefore doubtful.

This subordination to design will not easily be accepted by scientists, and designers will not accept easily that they cannot be considered as scientists.

§ 2 GENERALIZING SUPPOSES GENERATING

Words generalize. They summarize a set of unique but similar experiences in a sound or code. A combination of words demarcates smaller subsets within these sets.
As a result, each succeeding word in a sentence limits the scope ('extension') of the previous words and vice versa. We can finally experience an increasingly smaller subset as a 'description' of a specific experience or imagination.

A description in words can therefore only arise from a combination of generalizations. You can make new combinations, but each subset is always composed of generalisable experiences that we already suppose to share through words.
Each subset of generalizations is also a generalization. What you call 'description' is then at most a 'circumscription'. This is sufficient for *generalizing* science, but not for *generating* design.

The language is a limited means of communication that can cover certain *truths* and untruths, but by no means all *possibilities*. It *suggests* that it can cover any imagination, but it does not have that misleading completeness. Your wild ideas were literate, focused and limited, as soon as you learned to read and write. What you could not speak about, you had to remain silent about.[a] But even Pythagoras, Newton, and Wittgenstein hid a mystical contraband under their lingual logic.

The meaning of words contains unspoken suppositions, images for which there are not always words. For example, the words 'mass', 'force' and 'energy' suppose indefinable assumptions, but in mechanics their *relationships* are definable and practically usable. This made some believe that relationships are more real than objects, but that moves the problem to the definition of the word 'relationship' itself. A 'relationship' supposes different masses, substances, objects, variables or whatever you want to call them, *between* which such a relationship 'exists'.

That therefore supposes, first of all, that they differ. Even in order to conclude an *equality* between objects, these must be *different* objects. Science is looking for similarities to be able to generalize them in 'laws', but designing is making a difference, otherwise it is copying. Difference itself is not a 'relationship' supposing objects; an object supposes a difference.[b] In this study into a 'practical' sequence of suppositions preceding each representation, not 'equal' and 'being' are taken as the starting point[c], but 'difference' and 'making'.

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a Free to Wittgenstein(1922)Tractatus logico-philosophicus Logisch-philosophische Abhandlung(Frankfurt am Main1963)Suhrkamp p115
b Connections and separations are relationships. A difference, however, may exist on itself, independent from what exists on both sides.
c That happened in previous attempts, such as the 'Konstitutionstheorie' of Carnap(1928)Der logische Aufbau der Welt(Hamburg 1961)Felix Meiner §108 p150, strongly oriented on Russell(1903) The Principles of Mathematics(London 1996)Norton. Russel §167 p179 also uses 'difference in the sense of dissimilarity'. 'Difference' is then derived from equality. In the negation 'dis', however, 'difference' is assumed.

New ideas cannot be derived from 'equal equalities' but from 'different differences' (among which equality) they can. This has consequences for the use of words such as 'relationship', 'property' ('characteristic') and 'category'.

I accept an outside world that differs from me. My mobile and transient impressions constantly provide news in a variety that I can not contain, let alone make up myself. I do not want to *reduce* impressions. I want to be able to *make* them. The purpose of this exercise is to eliminate suppositions that obstruct our imagination of possibilities.

§ 3 DESIGN SUPPOSES POSSIBILITY BEYOND THRUTH OR PROBABILITY

The role of designers and their inventions in world history is overshadowed by their economic, cultural and administrative *effect* after realisation. Their users, applications and effects fill the history books. Only footnotes refer to the designers and their designs as one-off events, mutations that do not lend themselves to generalization.

My Dutch countrymen even forget the inventions with global effect from our own country, even though they now determine our daily lives, and even though they have made the stormy development of science possible since the Renaissance.
This development has been made possible by *designs* such as the printing press[a], the telescope, the microscope[b], the pendulum clock[c], the steam engine, the transistor, the radio telescope[d], the particle accelerators[e].

Scientific hypotheses and methods are also invented instruments that subsequently make discoveries possible. They are designed separately from their later applications: the mathematical notation, the use of coordinates, the empirical cycle, the theories, the experiments with which they have been tested, the mechanics, the thermodynamics, the theory of relativity, the atom model, or quantum theory.

Yes, science itself is not a natural phenomenon that has been discovered (found somewhere), but a human design, an instrument for reliable and valid truth-finding.[f] However, the *design* of an instrument requires other skills than its *use*.

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a Germans, Dutch and Flemish people are still fighting for the honor of having been the first with their inventors Johannes Gutenberg, Laurens Janszoon Coster or Dirk Martens.

b The microscope (1595) and telescope (1609) were invented in Middelburg by Sacharias Jansen. By the telescope, Lipperhey and Metius are also called Dutch inventors. With a telescope from Middelburg, Galileo learned from planetary orbits to understand valleys to refute Aristotle's centuries-long suppositions. With the microscope Van Leeuwenhoek opened up microbiology

c A patent from Christiaan Huygens, who also introduced the use of mathematical formulas in physics.

d Originating from an important discovery by the Utrecht astronomer Henk van de Hulst in 1944, when he still studied in the war isolation, undisturbed by the stray light of publications, with Marcel Minnaert in the Utrecht Observatory. On the roof, thanks to the obscuration enforced by the occupying forces, the students were able to see for the first time the stars that were previously hidden by the stray light. Thanks to his work, the Galaxy was charted with radio telescopy after the liberation.

e An instrument to which the Delft engineer Van der Meer made contributions with which he shared a Nobel Prize in 1984. This demonstrated the particles previously predicted by the Utrecht Nobel Prize winner 't Hooft.

f How design and scientific research can go hand in hand and have a direct effect on history is perhaps proven most impressively by Flemish-Dutch genius Simon Stevin. He wrote out of conviction only in Dutch, so that his ground-breaking inventions and discoveries for foreign countries remained hidden for a long time. They gave the young Republic of his pupil Prince Maurits a decisive lead in many areas and it would not surprise me if we had passed the 80-year war by such a free-thinking élan. These were fairly underestimated innovations in mathematics, mechanics, hydrostatics, astronomy, geography, maritime science, technology, martial arts, accounting, architecture, music, sociology, logic and the Dutch language. Dijksterhuis (1943) Simon Stevin (The Hague) Martinus Nijhoff, needs 600 pages to do justice to him.

MAKING POSSIBLE SUPPOSES CREATING CONDITIONS

A house is not designed to *cause* a household, but to make different kinds of households *possible*. It creates conditions for a household but it does not determine a specific kind of household.

The difference between *cause* and *condition* is crucial for the distinction between empirical research and design study. A cause is a condition for an event, but not every condition is also its cause. By 'condition' I do not mean primarily the logical condition with a *truth* value ('if ... then', 'then ... if' or 'then and only then ... if'), but a 'practical condition' with a *possibility* value: not 'if x then y *true*', but 'if x then y *possible*'.

The 'practical condition' does not conclude, does not generalize, but it generates, specifies, makes feasible in a constructive series. I will use the term 'condition' in this sense, unless otherwise stated, or if the context shows otherwise. Suppositions are conditions for imagination. You can imagine something only on the basis of all sorts of hidden, self-evident or learned pre-suppositions. There are, however, also assumptions[a] *limiting* that imagination and thus blocking our design skills.

DESIGN DOES NOT SEEK ONLY TRUTH OR PROBABILITY

A design is not a prediction. Yet the designs themselves, including the inventions that have made discoveries possible, are generally regarded as the scientific results of seeking truth or probability. *That is a false assumption.*

The printing press exposed opinions to broad criticism, a condition for modern science. The telescope brought Galileo closer understanding of planets, their orbits and valleys. With his microscope Van Leeuwenhoek gave the go-ahead for microbiology. The pendulum clock of Huygens made exact time measurement possible. The numerous electrical experiments with strange, often useless instruments preceded the theory.

Thermodynamics came forty years after the steam engine. Shortly thereafter followed the combustion engine of Nicolaus August Otto[b], a grocery without an engineering degree, whose invention lives on today and in detail in our cars. The theory of relativity was designed by an inventor of refrigerators[c], working on a patent office, before its validity was proven. This required more creativity than purely empirical research required for the final proof of its operation in reality.

A theory is designed once and tested repeatedly with designed instruments. Previous hypotheses are not discovered, but designed as a possibility. Their 'truth' (operation) is only 'discovered' by empirical research. The hypothesis gives direction to the research question. The assessment, preferably by others and in any case with an attitude other than that of inventors, requires verifiable reliability and validity.

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a I do not yet use the word 'supposition' here. I reserve this for conditions making our imagination possible as underlying stones in a construction. An 'assumption' than is an arbitrary, non based statement 'taken for true', in a logical reasoning or taken as (im)possible in a design.

b https://nl.wikipedia.org/wiki/Nikolaus_Otto

c Schils(2008) Einsteins koelkast(Diemen)Veen Magazines

1 SCIENCE SUPPOSES DESIGN, NOT THE REVERSE

The inventors have undoubtedly made *use* of previous scientific discoveries and results, but designing is more than just use. Scientific research is part of that more comprehensive, typically human imagination that we call designing, and not the reverse.

Truth-finding leads to fixed, broadly shared assumptions (paradigms) that can even stand in the way of that bold ability to imagine unlikely, *improbable* possibilities. Designers must dare to disregard standard suppositions, simply forget them or replace them with others, to come up with something new. Some call it 'reframing', but it is not just about the framework.

FOLLOWING AN EMPIRICAL METHOD, YOU CANNOT LEARN DESIGNING

Everyone looks for opportunities in daily life, *designs* them before they are realized and used. Searching for truth is a laborious part of this, but *possibility* includes more than truth. You may *know* what is already there. You have to *make* what is not yet there. You can know, but you know not can. There are widely accepted methods for 'knowing', but 'being able' should be practiced by doing.

Some designers have made their job of looking for new opportunities. How did they learn that? In the design training of my university we followed lectures of researchers and designers in the morning. This was mostly about existing designs and techniques, but art history does not make artists yet. In the afternoon we made designs ourselves, under the supervision of design teachers in studios.

In that other world of design studios little reminded of the lectures in the morning. This medieval scholastic sequence ('lectiones ' in the morning, 'disputationes' in the afternoon) can be better be reversed in design education. Designing raises questions. Answers do not produce designs.
The design teachers each told their own story. It even seems as if there are as many methods as designers.[a]

The research teachers were more unanimous. They were empowered by the empirically trained specialists with whom the teaching team was expanded to make the program more 'scientific'. This way, it could happen that design is now mainly taught according to the lines of empirically inductive and deductive research (problem definition, objective, etc.).[b] That is also expected from a university. It just does not work.

Designing is more than induction and deduction. It is also more than abduction (**Fig. 40** p37).[c] There is much literature about existing designs, much less about how you make them. We can know, but we apparently cannot 'know' the prior 'can'.
How should you *learn* to design? In order to unlock possibilities you probably also have to *un*learn things.

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a S Jong; Voordt(2002)Ways to study and research urban, architectural and technical design(Delft)DUP p20 http://www.taekemdejong.nl/Publications/2002/Jong(2002)WaysToStudy(Delft).pdf

b Simon(1969)The Sciences Of The Artificial (CambridgeMass1982)MITPress p36 'Heuristic search... is in fact the principal engine for human problem solving ...'.

c Among others defended by Dorst (2013) Academic design (Eindhoven) TUE Inaugural address. It is impossible, however, as a designer of *possibilities* to derive a methodological justification from the *truth* logic. (See further Fig. 3 p8 and note qqq op p44)

THE OBJECT AND CONTEXT OF DESIGN BOTH MAY BE DETERMINED OR VARIABLE

You can distinguish 4 types of design-related study.[a] The English distinction between 'research' and more ecompassing 'study' makes sense. If the object is already designed, and thus known in detail, then you speak of 'research'. If the object is still variable, then it is 'study' (the columns in ***Fig. 2***). There are two variants of both (the rows in ***Fig. 2***).

The physical, technical, economic, cultural and administrative **context**[b] can be determined ('known'), or still variable also. If the object and the context are known, then you may speak of 'design *research*', a kind of (art) history.

		OBJECT *Determined*	OBJECT *Variable*
CONTEXT	*Determined*	Design research	Design study
	Variable	Typological research	Study by design

Fig. 2 Types of design related study

If it, however, concerns known objects in *different* contexts, then it is more professional 'typological *research*'.

Both are characterized by an empirical method, but this method is inadequate if the object is still variable. In an ordinary design assignment the *context* is known, but the *object* varies in the head of the designer ('design *study*').

However, important inventions have also been made in which even the context of the variable object was not yet determined. The inventor had no idea in which context his object could ever be used ('*study* by design').[c] I have in mind the electrical experiments of the 18th century. Nobody had a valid idea of the object 'electricity' and of the countless contexts in which it would prove its use in the centuries thereafter.

DESIGN CRASHES IN EMPIRICISM

My doubt goes beyond a design training that crashes in empiricism[d]. Design study requires an imagination that goes beyond the mass of circulating ready-made images via various media. Such representations do not train your own imagination.
They discourage it.

Our representations have already been uniformed by the linear language in which we communicate and generalize, the logic by which we are convinced, the cliched learned prejudices and collective errors that we do not know because everyone has them.
There are many learned and forced assumptions that we are not aware of.
They can, as seemingly self-evident paradigms, imprison and stifle our imagination for a long time. They then stand in the way of developing design and science.

a Jong, Voordt eds (2002)Ways to study and research urban, architectural and technical design (Delft) DUP Science p20
b 'Context' refers in principle to a textual environment, but this concept will be used in a more general sense of 'environment'.
c Hintikka(1985)Logic of discovery and logic of discourse(New York)Plenum Press is about answering a question, solving a problem and not about making a design.
d Winy Maas outlines the limitation of the Delft architectural education as "... coming up with solutions to problems …". Hannema (2017) Land van Maas (Volkskrant) 1014

Which assumptions do so? A fish does not 'know' what water is, until it is removed into the air. It thus comes into a different world in which it can no longer live.

For people, on the other hand, it could mean a rescue. Which assumptions have kept us under water for such a long time? How are we again susceptible to Prometheus' fire? How can we get air and land on the vast terrain of improbable opportunities? The unlikely nature and chemistry of living organisms is at the forefront of showing possibilities that no human being could have imagined before.[a]

SUPPOSITIONS CAN BLOCK DESIGN

Since the miracle of Renaissance until the first half of the 20th century, inventions and discoveries have eliminated many blocking and incorrect assumptions. The design called 'science' was an instrument to expose false assumptions, to make us immune to them and to shake up our imagination.

That role seems to be played out, although there are exceptions, such as the continuing stream of fascinating biological discoveries and medical inventions, which dominate the science supplements in the papers.
Fantasy and games sell better than science. There are few directly 'relevant' discoveries for sale. The technique only provides commercially interesting improvements (or combinations) of already existing and long-standing inventions.[b]

Direct socially relevant outcomes of scientific research are context-dependent. They are therefore immediately scientifically questioned in other contexts. This undermines public confidence in the current truth-finding. What is universally generalizable is largely generalized. A local *average* is still commercially interesting, but the excessively distant remainder of the *singular* is not supported by statistical reliability.

What remains are special cases in which many uncertain context variables play a role. 'New inventions' now combine and miniaturize mainly inventions from the last century (internet, iPhone). That is rather management than design. Futile variants in turn become a good selling hype. Groundbreaking design requires greater deviations that dare to evade conventional suppositions.

There are more myths in the world now than in the time of Thales of Miletus 600 BC. They grow from the ground like mushrooms. Summer is over. Their commercial roots reach into science. You have to go through her disciplines one by one to see where their innovative potential has been affected.

§ 4 CONDITIONS MAKE POSSIBLE AND IMPOSSIBLE

EVEN DESIGN INSTRUCTIONS MAY BLOCK IMAGINATION

In design practice, many regulations apply, developed by empirical research. They prevent errors from past contexts with undesirable consequences. That is useful, but

a They therefore form a growing source of inspiration for the technology ('biomimetics' or 'biomimicry'). See for example Lems (2009) Thermodynamic explorations into sustainable energy conversion (Delft) TUDthesis.
b All great inventions have been made by now: Noort(2016)Gordon: Alle grote uitvindingen zijn inmiddels wel gedaan(NRC)0319

they can also deprive the view of exceptional opportunities in other contexts. There are enough prescriptions now. To dictate more to a designer than what years of education of commandments and prohibitions have already yielded is dangerous because it limits unexpected possibilities.

In design education regulations of 'prescriptive knowledge' will play the role of tacit assumptions and prematurely block imagination. A great challenge for design students would be to analyze an existing facility or existing tool, make the assumptions explicit, omit at least one, to design something similar without that assumption(s).

I would therefore not like to speak of prescriptive knowledge, because knowing belongs to a fundamentally different modality than designing. With design and technology it is about imagination and skill. That imagination is captured by hidden assumptions no longer under discussion.

Generating is at odds with generalizing. 'Ceteris paribus' is seldom right. There are circumstances in which the general does not apply.
You should not let go exceptional opportunities. Avoiding risks is risky itself.

Regulations are not true or false. They belong to the modality of the desirable. Know-that belongs to the modality of what is true, probable, untrue or unlikely.[a] Know-how is dualistic. As far as it concerns routines with a fixed result, it is a historical science of existing recipes. From history, however, you can often learn better what to avoid than what to do.

The current administrative, cultural, economic, technical, ecological and physical context is decisive for the success of such routines. Know-how includes more than know-that and routine. Insofar as know-how does not involve routines, it is part of the exploration of the third modality: *possibility*. In order to know how to explore the potential within a given context, you first have to understand that context and sometimes thoroughly analyze it.[b]

SOME DESIGN CONDITIONS MUST BE DELETED

There is no doubt that designers use the results of empirical research intensively, but their own work differs fundamentally from that of their suppliers. A researcher searches for truth, probability and sometimes desirability. A designer looks for possibilities, as far as they are not yet true or probable, and even not necessarily desired consciously by anyone.

A designer and particularly a designer of multifunctional facilities,

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a The fact that 'truth' itself is a modality is contrary to prevailing views in modal logic (p49). Modal logic would take a completely different form if truth (according to Fig. 3 p12) would be taken as a limited and limiting part of possibility.
In the current 'alethic' modal logic the truth logic is valid in all possible worlds and thus a limitation of possibilities.
Of these, the laws of nature are a ('nomological') part and also universally 'necessary'. However, they are both part of our language ('analytical possibility') and our sense of existence ('metaphysical possibility'), which in the alethic vision are also included as necessary in all possible worlds.
The 'possibility' that I hold here concerns (more broadly that alethically) the possible worlds in which 'actions' are possible, changes that can be set in motion by someone or something. I call that 'practical' modality with 'practical' conditions.

b Jong(2007)Operational context analysis as a part of design related study and research(Zoetermeer)WSEAS EEED '07

1 should not isolate a singular problem from a field of problems that can be solved together;
2 is not allowed to isolate a singular goal from a field of diverging objectives for diverging interests;
3 does not only work in a goal-oriented way, but also in a means-oriented way (looks at what is possible);
4 can not formulate a research object before it has been designed, before the work is done: that object varies in thought and gradually develops from vague to concrete by looking, sketching, calculating, reading and writing;
5 has as its starting point only a context with many variables on different levels of scale;
6 brings together explicit and unspoken administrative, cultural, economic, technical, ecological and physical problems, objectives and means from this context in a concept, a representation or proposal in which more stakeholders can project and weigh their own (sometimes unforeseen and unspoken) objectives;
7 such a concept produces a general hypothesis that is hardly worth mentioning: 'This will work';
8 therefore has starting points different from a clear object definition, problem definition, objective, hypothesis, a representation of how facts must be collected, arranged and related to each other;
9 has many methods to arrive at a concept: from material, form, structure, function or intention, in all conceivable orders and intensities of this series;
10 has more references than written text: images, forms, types, models and other concepts;
11 uses notions that are generalized or not in everyday language as words, in more meanings,
12 that change meanings per scale level and per unique context.

This does not correspond to the current assumptions of (conditions for) valid and reliable science. How, for example, do you start without a clear problem and objective, even without a clear object of research? The beginning is before all that. Those common assumptions have an order that deserves doubt. What does a problem, a goal, an object itself actually mean?

The target field aims at solving different problems simultaiously, if at least (with the means that language and drawing offer us) a possibility of solution is conceivable. Problem signaling, however, does not escape an analysis of missing conditions. As a result, the *coherence* of problems becomes design-relevant. The target field stands out as a system of realizable conditions, hypotheses in which some goals even seem to have been realized already in a solution.

You can not keep problem, goal, means and hypothesis separate as in classical scientific research.
More or less in the order of the above 12 points I will give below my preliminary

analysis of the usual assumptions that play a role here. They then form a problem field for the following chapters.

PROBLEM FIELD AND TARGET SUPPOSE MODAL SUBSETS[a]

Any true or at least probable statement is by definition possible, but not vice versa. The probable futures are a subset of the practically possible futures (**Fig. 3**).
There are also improbable possibilities. Because they are not true or probable, you can not predict them causally (from known cause-effect relationships). You have to design them: outline conditions to make something possible.

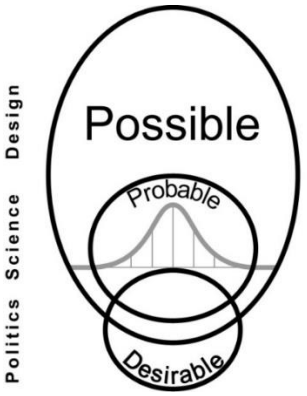

Fig. 3 The modal place of problem field and target field

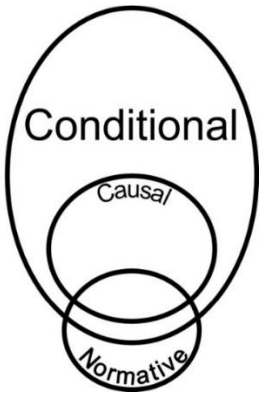

Fig. 4 Modally limited ways of thinking

Thinking about conditions of opportunity differs from causal thinking (***Fig. 4***). A house does not *cause* a household, it makes different households *possible*. Deciding whether you *want* a household also requires a different way of thinking ('modality'). Many desirable futures are not practically possible. Forget about them.

Other desirable futures are probable. Do not attempt anything, because it will probably also happen without your input (many people are doing so without effect). Do not act until there are probable futures that you do not want (problems) and if there are also improbable possibilities that you want (goals, target field, ***Fig. 3***). Design them.

Designers look for improbable opportunities. If those possibilities were likely, then they would not be designs, but empirical predictions. Moreover, they are looking for something other than what is already there, making a difference. Otherwise, their designs would be copies.

The old discussion if design is a science, and therefore can be taught at a university, is easily solved if you accept that science itself is a design, and thus part of design, not the other way around. A design is not a scientific product, science is a product of design. Such a conclusion will not be accepted by everyone.

a Cited with own changes from Jong(2012)Diversifying environments through design(Delft)TUD second thesis p16

1 SCIENCE SUPPOSES DESIGN, NOT THE REVERSE

THE CONCEPT OF 'OBJECT' IS PARADOXAL BY DIRECTION AND SCALE

'Object' is not the self-evident concept that most authors take for granted.[a] It has tacid suppositions. As a newborn (still without references) you will probably not immediately see separate 'objects' in the multiplicity of impressions that you get 'pre-cast' (object is literally pre-cast). This discernment must be *learned* as a representation in a long-term repeated sequence of tactile and visual impressions.

This well observable process in babies sheds some light on assumptions of which we are no longer aware of as adults (Chapter 5 p70). An 'object' in our first phase of life is the part of an incoming image that separates itself from the rest ('everything except' or 'not' the object), by 'parallax exercises'.

When you move, you see something in the foreground appear more quickly than the background, but when you follow that object with your eyes, the background moves in relation to that object ('object constancy'). That active separation (loosening, dis-connection, dis-traction, abs-traction) supposes the observation of permanent differences in all directions despite motion.

This also sets the foundation for the conjunction 'not' (everything except the object). 'Not' leaves everything except the object undetermined. The 'attention' focuses on an object ('focus'). The loosening of an object that is no longer perceived (eg learned with the game 'peek-a-boo'), requires a stack of abstractions that gradually under-lie (are sub-posed in) concrete impressions and experience.

Parallax, however, does not help anymore in the recognizing of a constellation of stars such as Orion, based on an arbitrary traditional outline of the figure. Many other outlines would have been possible. Such arbitrary outlines are taught by culture and become sup-posed in the observation.

The abstraction technique for deriving object constancy is simply repeated in non-concrete representations, even if they are only real as (often taught) internal representations (re-presented, brought back to present). Two paradoxes appear when distinguishing objects: a perpendicularity paradox and a scale paradox.

DIFFERENCE SUPPOSES PERPENDICULAR EQUALITY (PERPENDICULARITY PARADOX)

An omnidirectional enclosing sharp outline of sudden differences between an 2D object and its environment (the difference between 'well' and 'not') does not take up any space. Each difference in the 2D surface supposes a direction. Perpendicular to that direction there must be less difference (some equality) in order to see the difference (***Fig. 5***).

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a Kant (1781) Critik der reinen Vernunft (Riga) Hartknoch, has said wise things, but in the course of his argument he tacitly passes a growing number of suppositions that I do not share. He laid down his foundation at least on the tenth floor. He does not mention underlying floors (the suppositions). As a result, he needs hundreds of pages of scaffolding to keep his building upright on skinny pillars.
One set of assumptions is tacitly stored in the term 'object'. Kant takes that concept everywhere for granted (as many do), but it is not. Recognition of an object and the detachment of that object from an environment full of differences, is the result of a long lasting learning process (p28).
Other unspoken suppositions at Kant are hidden in concepts such as substance, logic, knowledge, the concept of 'concept' itself, and of course also in its categories and judgments (***Fig. 247***, p92).

The kind of difference may be direction-dependent, as long as there is a continuous difference (last figure of ***Fig. 5***).

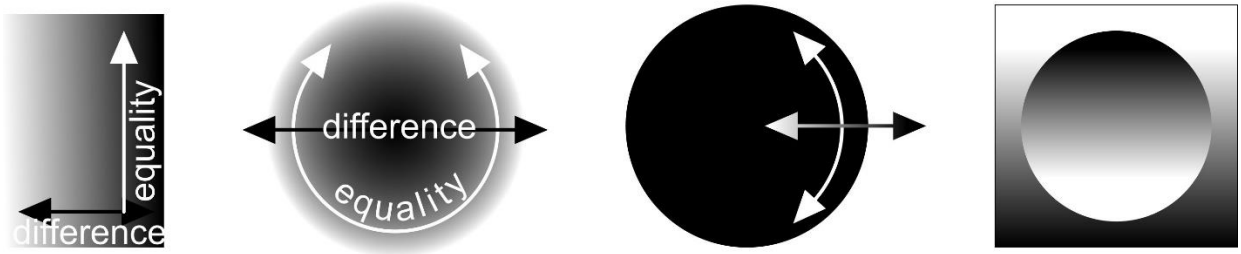

Fig. 5 A perpendicularity paradox in vague and sharp object boundaries

This perpendicularity paradox applies also in space taking vague boundaries and in 3D. It is immediately clear from a 2D drawing, but in a linear language this perpendicular relationship can lead to contradictions. 'The bridge is open' says the skipper. That is at odds with what the motorist reports. Who is lying?

INTERIOR SUPPOSES A CONTRARY EXTERIOR (INSIDE-OUTSIDE PARADOX)

There is also an inside-outside paradox, which produces a seeming disagreement. A ball is hollow, seen from the inside, but convex from the outside. The impression changes drastically coming out, but entering the difference itself remains the same in the opposite direction (symmetry). A linear verbal representation may distinguish a difference 'from black to white' and its reverse, but an image does not prescribe a direction to see the same difference.

Going out from home is like a birth. To step out is called 'ex-sistere' in Latin and 'ek-stasis' in Greek. Existence and ecstasy have the same origin.

DIFFERENT DIRECTIONS ALLOW CONTRADICTIONS

'I lie' is a double message. If I tell an *untruth*, then it is still *true* that I am lying. One message is about the action of my lying (true), the other is the lie content (false). One message ('meta-language') is about the outside, the other ('language') about the inside. A child knows such a thing as it builds huts or tents and experiences the above-mentioned inside-out opposition of viewing direction as coming out and entering (eg light | dark).

Something similar happens when we think *about* 'thinking' (philosophy, psychology). The second 'thinking' is the content, the first supposes what we want to say *about* that 'thing'. We must then be prepared for apparent contradictions (paradoxes). When we say something 'about', it suggests that we look at it 'from above' and that is 'at right angles' to the area being looked at. Whether that content is true or false, *that* I think about it is true (the 'cogito' of Descartes).[a]

So you can tell truths about truths, truths about falsehoods, falsehoods about truths and untruths about falsehoods.

a The latin background of cogitare (co-agitare, thinking) is interesting: 'repeatedly acting with'. For the Romans thinking was apparently acting parallel to reality. I will indicate it further with 'co-action'. 'Inventing' or designing would then be counter-acting to reality. Designing is then indeed 'ejecting' from an existing reality.

Can the past be 'true'? If you talk about something, it is already a thing of the past, no longer accessible to your own action, no longer 'actual'. Even a football reporter can only tell what happens if it has already has happened. We are only convinced of that unreal past when more sources tell the same thing, but those stories can not be chequed or tested because they are no longer accessible for such a controlling *action*.

Moreover, every memory is based on a flat image[a] of which, in spite of all kinds of additions and associations, little remains. The sequence of memories as a stack of photos is then 'perpendicular' to the images. The three spatial dimensions are 'perpendicular' to each other, perhaps the fourth (time) too.

A JUDGEMENT MAY TURN INTO ITS OPPOSITE BY CHANGE OF SCALE (SCALE PARADOX)

If you observe the pattern in **Fig. 6** In detail, then you only see differences: every black dot has a white one in its surroundings and vice versa, but at a distance you see equality.

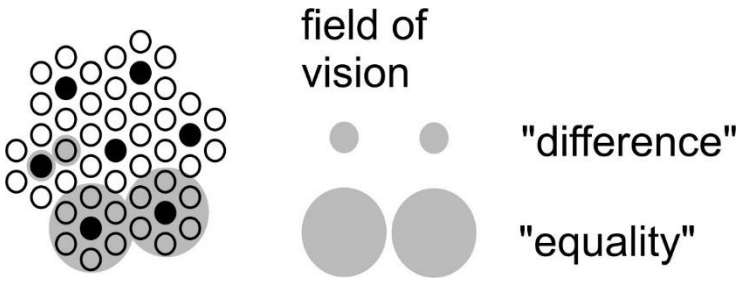

Fig. 6 Scale paradox

The judgment 'difference' or 'equality' can therefore be reversed already at a linear scale difference factor of 3. That is a minimum and only a possibility, but there are 10 decimals between the size of a grain of sand and of the earth. These are at least 20 factors 3. So there are in theory more than 20 possibilities to disagree, while you actually agree, if you keep an eye on the scale of the claim.

The scale paradox leads to senseless differences of opinion. A street with all different buildings looks like other streets with such an arbitrary mixture of buildings. Paradoxically, some equality between buildings in each street is required to distinguish the difference from other streets. An urban planner who complains about the characterless uniformity of the streets will therefore disagree with the architect who enthusiastically praises the individually different character of each home.

Meaning rests on suppositions. With other scale suppositions, the meaning can change. If your conversation partner is arguing with *two* reversals above the scale you have in mind, then you can even agree with each other while you do mean something different.[b]

With the insight of the scale paradox, I do not have to assume mystical forces like an 'invisible hand' of Adam Smith in the economy or the 'self-organization' of 'complex

a A memory is also largely coming from the flat retina or flat skin. The third dimension must then be a construction with (possibly remembered) experience of our own movements (motor skills).

b This also applies to the exchange of cause and effect on different time scales. See for example: Jong(1998)Wat eerst: wonen, water, wegen of welvaart In Angremond Editor Watertovenaars Delftse ideeën voor nog 200 jaar Rijkswaterstaat pp 42-52(Delft)

systems' that astound physicists when they observe sudden order ('synergy') in microscopical chaos ('emergence', a 'phase transition' such as freezing, p180) under certain macroscopical conditions.

The scale paradox does, however, give rise to the relevant question what 'disorder' and 'order' exactly mean. In physics, 'disorder' ('entropy' S) is a probability of distribution (p171). An orderly state (all gas concentrated in a corner) is improbable (low entropy).

In computer science, the amount of information which is at least necessary to describe a system (H, expressed in 'bits' p174) is intended analogously. Disorder requires more bits than order. If in a larger radius one or another repetition appears, then you can suddenly describe the system with fewer bits ('information compression').

Both kinds of 'order' are different from 'organization' between different organisms or different organs with different functions. In ecology this is seen as a valuable, less chaotic increase in the information content of a system. A phase transition to less biodiversity may mean more order, but also less organization.

An ecosystem with few species is easier to describe with addition and multiplication than an ecosystem with many species and many different mutual relationships. There is then plenty of reason to shift the attention to rare organisms and unlikely situations. That is also typically the focus of designers.

Self-organization then is a misleading term feeding the risky confidence of laissez-faire liberals. I would prefer to speak of repetition, regularity or coordination that can occur in large numbers of particles, individuals or waves as a sort of resonance in a laser, or in a 'wave' in a football stadium (simply because you do not get space enough in the opposite direction).

It is questionable whether 'self-organization' is desirable, if it means extinction of deviating categories. 'Synergy' in the ecological sense of symbiosis with mutual benefit between different species is just the opposite.

'FUNCTION' HIDES SUPPOSITIONS OF SCALE, DIRECTION, CONTEXT AND STRUCTURE

Any 'function' supposes a level of scale

A good example of change of meaning through the scales is the concept of 'function', so often used in designing.[a] This change of meaning is already detectable linearly by a factor of 3 (around 10 in area), be it often unnoticed.

What is the function of a brick (nominal radius[b] R=10cm), a window (R=>30cm, a door (R=1m), a room (R=3m), a house (R=10m), a building complex (R=30m), an

a That function concept for the design is central, for example in Kroes(2006)The dual nature of technical artefacts(Studies in History and Philosophy of Science)0301 Vol 37 nr 1. In this, hardly any attention is paid to the scale on which people can speak of 'function'.

b With this 'nominal radius' R is meant here an element from a series of dimension *names* that each do not exactly represent the radius of the circumscribed circle, but a radius that lies between the previous R and following in that series. A small r then concerns the inscribed circle (resolution).

b With this 'nominal radius' R is meant here an element from a series of dimension *names* that each do not exactly represent the radius of the circumscribed circle, but a radius that lies between the previous R and following in that series. A small r then concerns the inscribed circle (resolution).

'ensemble' (R=100m), a neighborhood (R=300m), a district (R=1km), a city (R=3km), a conurbation (R=10km), a metropolis (R=30km), a region (R=100km), a country (R=300km), a continent (R=1000km), yes, what is the function of the world?

Any 'intention' supposes functions and therefore a level of scale
The term 'function' is often understood 'teleologically' as purpose. I can, however, imagine unintended functions, but I cannot imagine an intention without intended functions. A design has more unintended effects than intended.
If intention *supposes* function, and function is scale-sensitive, then 'intention' is also scale-sensitive.

Politics is a good example of scale-sensitive intentions.
If you define 'politics' as looking for an answer to the question 'What should everyone do *for themselves* and what should we do *together*?', then scale-articulation is necessary to distinguish intentions. What do we do together at the level of a house, building complex, ensemble, neighborhood, district, city (municipality), regionally, nationally or internationally and what are we going to decentralize again?

Every political party assumes scale levels in its program where 'for themselves' and 'together' acquire a different meaning.

The meaning of 'function' changes from physics into humanities
Administrative, cultural, economic, technical, ecological and physical *functions* differ substantially in meaning. Moreover, at every level of scale any of these functions can get a different meaning and priority or dominance.

'Function' hides an inside-outside paradox
If you define 'function' as operation or working, then you should distinguish an inward and an outward function. A house has an inward function for its residents, but also an outward for the neighborhood, the city and so on.
A car is *constructed* and *used*. Its internal structure should fulfill the function of moving a mass, but it has also an external function for a family, a business, a city and so on. A ball is hollow to function light and elastic and convex for playing.

'Function' supposes structure
I can not imagine a function without an external *structure* (a set of connections and separations) within which it operates (eg a manager supposes an organization, an aeroplane supposes airports and free air). A function supposes, however, also an internal *structure* (its construction) through which the facility can operate at all. On its turn, 'structure' supposes a dispersion in space and time, a 'form(ation)'.
'Function' therefore also supposes 'form'.

Combination of functions saves space, specialization saves time.
This may be a bold statement, but it is an actual dilemma in many designs. 'Function' supposes dispersion (form) and duration (formation) in space and time. In many contexts space and time are precious resources. The statement supposes some ('perpendicular'?) complementarity of functioning (***Fig. 48*** p53).

The mathematical function reduces 'function' to operations on numbers
This limited use of the concept 'function' is elaborated in chapter 6 p153

ANY DESIGN IS MULTIFUNCTIONAL
In order to design a non-existent object, you can start with the function ('functionalism'). That is a widely used methodical goal-oriented start. However, there is rarely *one* 'monofunctional' function or operation at issue.
There are for example always financial consequences and there are often more stakeholders with different intentions (built upon the different suppositions mentioned above) enabling to use different functions of the same facility.

In this way, each design is in principle multi-functional. A program of requirements is an enumeration of desired functions, but that is seldom complete if you take every scale, direction, context and structure into account. Some functions are so obvious that they are not in the program for a home. The designer also often finds function possibilities that no one has anticipated, such as a door in which you can also sit[a].

If the overview of all these functions in the target field is no longer guiding because of the multiplicity, a designer can also start in a resource-oriented way with available contexts, materials, possible forms or structures.
A sketch of shapes or structures can sometimes suddenly offer space to all requested functions in unexpected combinations and still add functions that fulfill unspoken wishes.[b] The program of stakeholders can therefore change.[c]

Content, form, structure, function and intention, as object layers of their own, suppose each other in a conditional sequence: no intention without a vague or concrete representation of some function, no function without structure in or by which it can function, no structure without a form (state of dispersion) in which it 'takes place' in space, and no form without material ('content') that can take this form.

This conditional sequence does not yet play a significant role in the order of the *design process*. A designer sketching forms is still free to alternate the focus arbitrarily to the content, structure, functions or intentions. This means that different skills are alternately adressed, and that can provide new perspectives and inspiration. The focus changes can follow each other quickly or slowly. That is why there are so many design methods.[d]

The conditional sequence is, however, important for realization, and in that sense a designer can anticipate this in the design process in order to shift focus once again. At the end of the design process it is a checklist to check the designed object for its practical-conditional coherence ('evaluation' afterwards).

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a An example from the lectures of Aldo van Eyck in the 70s at the TUDelft about the huts of the Dogon people in Mali.
b Designers of a new large urban district (I will not name the location) stated that they had not studied the piles of municipal files with requirements and wishes, when they surprised the stakeholders with a design, that almost all requirements and wishes had been met.
c Jong;Voordt(2002)Ways to study and research urban, architectural and technical design(Delft)DUP p271.
http://www.taekemdejong.nl/Publications/2002/29 PROGRAMMING OF BUILDINGS from Jong(2002)WaysToStudy(Delft).pdf
d 'Meta-hodos' is Greek for 'the way along'.

A similar conditional set of possibility conditions exists for the *context* in which the designer is placed with a not yet developed object at the beginning of a design process. There are physical, biological, technical, economic, cultural and administrative conditions that suppose each other in this order.

At least I can not imagine a management if there is no culture (authority, language, motivation) that carries it. I can not imagine a culture that can maintain itself without an economic base, no economy without the existing technology that makes it possible, and so on.

The estimation of such a context and the utilization of its possibilities requires again different specific skills from a designer, prior to those required for the determination of content, form, structure, function and intention in the design process itself.