Preface

Dear readers, please wait a moment, and allow me to calm down the angry young man there in the background first.

> *´Dear young man, you did a nice job in 1978, but you have made your thesis too complicated and too simple. You have produced many superfluous pages, you have invented many useless terms, and you have left many gaps. Now in 2012 I can answer many of the questions you have left unanswered, or even unquestioned.*
> *As a supervisor, to be honest, I would not accept such a thesis. Nevertheless, you showed more awareness about levels of scale than your colleagues. Your framework and table of contents are useful, sound and simple. The terms you used: content, form, structure, function and intention, are common; everybody uses them. However, you where right that they have to be elaborated more precisely and bound to scale. Many design-related theses can be written within this framework. I realised that you have written the study programme that I have followed until now. I thank you for this early insight and direction. I am probably even more scared about the increasing homogeneity of our environment (endangering biodiversity and the freedom of choice for future generations) than you are. I continued your search how to increase environmental diversity by design during the time since you wrote your Dutch thesis ('Milieudifferentiatie'). Now I have written my own thesis ('Diversifying the environment'). It deserves another defence. I have used your table of contents, but, believe me, the content itself has had to be completely re-written. You would have been fascinated and surprised, as I was, rewriting it. You did not realise in 1978 what I have since discovered. For example, a written and spoken language on its own fails to describe crucial diversities, this is where you failed. You still trusted the limited capacities of words. I thus have included some of your drawings, but I also improved the others, and I substantially extended their number and content. These drawings are crucial for this thesis, for design in general, and for a science coping with possibilities rather than extrapolating past truths into probabilities. Words name equalities. Equality is a special case of difference, not the other way around, as Chris Van Leeuwen already suggested to both of us. Our senses observe indescribable differences, unacceptably reduced when described through written word. Our designs make something different, not something equal. Designing is not merely copying or combining old things. It is not sufficient for the problems which we face this century. Designing is coping with possible futures, not only with the probable ones. Our probable futures are a tiny part of the possible ones. Looking for probability or 'truth' based equations hampers our view on the inconceivable diversity of possible worlds. It is the core of design to provide improbable possibilities.*
> *We thus need images rather than words.*
> *Dear young man, one of your possible futures has become my past. It has become largely probable now. The result is again an intermediate stage. Others may take the next step. One day they may speak to me as I did here to you. Let me report to them where we are now to enable them to proceed. After this short justification of what I did with your work, I have to leave you now. The readers are waiting.´*

Dear readers, thank you for waiting. As you may have understood, this thesis is not an attempt to find any truth or its approximations by probability as usual in empirical science. It explores possibilities. Extrapolations of existing probabilities into the future are possible by definition, but not the other way around. What is possible is not always probable. Probable futures even cover only a tiny part of the possible ones.

The scope of probability search

It is the task of empirical research to find probabilities, but it is the task of design to find improbable possibilities. The number of probable futures for the Earth, for its separate continents, their separate countries, towns, households, individuals, their artefacts, materials and so on, is inconceivably large. Predictions for the next moment are more certain than for the long term, but paradoxically less certain for individuals than for the Earth. Smaller uncertainties and differences become insignificant as the scope of focus shifts to a larger scale. Our window of attention does not contain anything larger or smaller than allowed by its scope (frame) and resolution (grain compared to the frame). A larger resolution would mean more detail, so smaller details would be noticed as the resolution increases, but the span of our senses and thoughts is limited. Fortunately, there is a reasonable consensus about scientific methods to make predictions (reduced imaginations of the most probable futures based on past experience). Some of these expectations frighten us. We inherently want to change them through design, and to realise less probable possibilities by action.

The scope of possibility search

There are, however, inconceivably more *im*probable, but still possible futures than there are probable ones. If our imagination is already taxed by the diversity of one history and many probable futures, then it certainly falls short imagining the diversity and multitude of *possible* futures. If we cannot *imagine* our alternatives, then we cannot consciously *choose* one of them either. We may overlook the most promising possibilities by lack of imagination, falling back on the *solutions* we know from the past. This century has other *problems*.
Every era in history has overlooked the improbable possibilities we subsequently developed into reality. They were available, but nobody could *imagine* them. Even designers are guilty of this lack of imagination. This thesis should enable to imagine more spatial possibilities, more environmental diversities. These possibilities and considerations are more necessary now than ever before. There is no hope for future generations to exist without diversity, and no chance for survival for other species. Diversity offers alternatives for survival in changing contexts. It is the strategy of life to prepare for, and find solutions to, risks.

Design methods

Unfortunately, there is not currently a method to identify improbable possibilities. However, there are widely accepted methods to identify probabilities or truth-finding. Perhaps a 'method' would even limit the number of possibilities you can find. This thesis thus does not describe design-methods as I had done previously.[a] There are many design methods. They are practiced, studied, recommended and applied in design education. They are mainly *aim*-directed as usual in empirical research. However, many great inventions emerged *means*-directed before they provided a target for research. Inventions often *preceded* scientific research. A properly working steam engine was invented by Watt 40 years before thermodynamics could explain its efficiency. The lightning conductor invented by Franklin motivated research on electricity. Faraday's dynamo preceded Maxwell's equations. Nobody knew what electricity was, nobody imagined any of its applications we now know. In the beginning its study was simply playing with electricity, without any intention of substantial use. The problem-aim-solution sequence was ineffective in identifying its *possibilities*, simply because nobody could *imagine* them. Improbable possibility search may *require* 'solutions in search of a problem', as it is often disparagingly formulated.

Possibilities of space

This thesis 'aims' to extend possibilities of spatial design that are useful in any design method. This 'aim', however, does not give direction to the study, as it usually does in empirical research. This study obtains direction by the *means* of spatial design rather than by its *aims*. Substantial design-means and -possibilities appear if you distinguish *orders* of possible diversity superimposed on each other: content, form, structure, function, intention.

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[a] Jong;Voordt (2002) *Ways to study and research urban, architectural and technical design.* (Delft) DUP Science

This sequence is not a method, but a consequence of expressing spatial imagination in a linear language. I cannot imagine intentions without simultaneous suppositions about functions. I cannot imagine functions without simultaneous suppositions about structures. And so on. This conditional sequence enables imagination by clarifying the preceding suppositions to be imagined first.[a] Problems and aims beforehand limit the *imaginable* set of possibilities, through hidden traditional suppositions about known functions.

Conditional thinking

If probability implies a causal sequence, then possibility implies a conditional sequence. However, in the conditional sequence applied in this study, 'intention' (containing the aims) is not the first condition (as usual in research), but the last. The possible functions of environmental diversity cannot be imagined without imagining the possible environmental diversity first. The intention or aim of environmental diversity cannot be imagined without imagining its possible functions. For empirical researchers, who silently suppose well-known functions from the past, this approach may seem bizarre: to postpone the aim of a study to the last chapters. However, in order to search for possibilities, this approach is unavoidable. Moreover, the study itself is a design. I do not know how it will be used. It does not *cause* a function; it *enables* functions. A house does not *cause* a household, it makes many households *possible*. The study of design possibilities consequently raises methodological questions about the second-order *design* of a study *about* design.
Its questions and limits, rather than its problems and aims, will be elaborated in Chapter 2.

Limits of language

Writing a thesis about *spatial* design raises substantial problems concerning the use of language. You may have observed already, that the English as it is used here betrays its Dutch background. It is not accidental. I did not always follow the formal translations of professional translators transforming my text into 'Scientific English'. Following a strictly truth-based logic, it sometimes extended my sentences and it darkened my intentions. Language is a bridge, not a barrier. And (o dear, a conjunction at the beginning of a sentence!), it develops by its use. My father's language (Frisian) developed into English, and English developed into many local kinds of English. The Latin developed into a mediaeval Scientific Language, and it was probably not even well understood by ancient Romans. For example, in many dictionaries, 'identity' is supposed to be derived from a Latin word 'identitas' meaning 'sameness' in a sense of 'identical'. However, if the police asks for your identity, it is intended to 'identify' you as *different* from any other person. Two opposite meanings of one word! When I looked in my Latin dictionary, I discovered that 'identitas' did not even exist in ancient Latin. I found 'idem(i)tidem' (repeatedly the same) instead. The etymologists apparently neglected the crucial 't' referring to itero and iterum. It refers to sameness in *time*, not in *space*. Identity thus is *difference* from the rest, *and continuity* in itself. This space-time paradox is one of the crucial problems to be unraveled in this thesis, and 'identity' hits its core.

Verbal language and drawings

My text should not be burdened by particular linguistic habits, even if it raises some prestige by its form. Extending sentences to proof your scientific standing is useless to transfer thoughts about design. The spatial idiom and syntax of design are different from *any* verbal language. It has been difficult enough to find words and sentences to express the non-verbal relations I had in mind. If they sound Dutch, than this may have the advantage to raise an awareness of hidden connotations different in different languages. I want to transfer no more connotations than strictly necessary, and sometimes to add unusual ones. Apart from this clearing faculty, a local colour may even have some added value for a thesis about environmental diversification. The English language has been a minor problem compared to

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[a] Jong (1992) *Kleine methodologie voor ontwerpend onderzoek* (Meppel) Boom
http://team.bk.tudelft.nl/Publications/1992/Jong(1992)Kleine methodologie voor ontwerpend onderzoek(Meppel)Boom.pdf

the use of verbal language as such. Two chapters were purified by professional translators. Giancarlo Mangone made the other chapters at least readable for the other native English readers. Paula van Gilst-Siliakus corrected my last failures. I am grateful for this effort, but also for the discussions with my old friend Christopher Vincent-Smith, being a native English speaker, balancing at the boundary of two languages with different connotations. His perfect understanding betrayed his background as a teacher in physics. Newton had to prune many usual connotations and even denotations of words such as force, mass, movement and acceleration before he could unveil their relations. Pruning the metaphors designers use may also unveil unexpected relations. The language of physics became mathematics. But, as I hope to make clear, even truth based logic and mathematics include suppositions a designer cannot fully share. Design goes beyond its suppositions of truth, probability and equality. In that context, a designer drawing objects that do not exist would be a liar. These objects are not true, not probable, and not equal to anything existent, but they are *possible* and *different*. Even physics has discovered the power of drawings to express structures[a]. Chemistry gradually experienced their inevitability as biology did from the beginning.

Forcing space into a time line of successive actions

A verbal language is primarily time based. The sequence of its expressions is directed in one dimension. A sentence cannot be understood backward, not to mention sideways. Its verbs represent *actions* of a subject on a target, and that may have been its primary function from prehistoric times onward. But, space cannot be forced into a time line. It cannot be described fully in terms of actions. The words used by designers betray their embarrassment to explain the 2D drawings they make. Their spatial thoughts are branched in space, but they have to prune essential side branches to fit them into a one-dimensional verbal sequence. The verbal argument does not cover the many side-roads shown in a drawing simultaneously. If a bridge is open into one direction, then it is closed in the other direction (direction-paradox). A road connects, but it separates in the direction perpendicular to its connection. The audience would ‘lose the thread’ of the argument, if a designer would mention every side-road jamming in direction-contradictions, even if they would support the spatially essential argument. Covering all routes and cross-sections of a drawing through speech would bore the audience. It would not even cover their visually obvious interference, their structure. A computer may show a picture on its screen in one long sentence divided in equal lines of pixels starting left-above and ending right-below, but they are related only in one direction by a simple syntax of sequence. The relations perpendicular to that direction become clear to the human observer only, and only if the lines are properly arranged. Understanding a spatial drawing requires more than understanding a sequence in time.

An escape into metaphors

Designers thus attempt to rescue their spatially branched arguments using poetic metaphors, branched into many accidental connotations. Nature is a rewarding source of metaphors. An inconceivable amount of forms and structures are available, and language provides words referring to some of them. If a building has ‘wings’, ‘embracing’ a square, then these metaphors may transfer a spatial thought in words useful to *sell* a design, but not to *make* it. Metaphors may be useful to extend your imagination in the process of design if verbalised thoughts prune your spatial imagination, but theyare not suitable to invent the possibilities of environmental diversification by design. Its exotic braches blur and limit the inconceivable diversity of *possible* contents, forms and structures you may handle in the making. May be any word is a metaphor, but the branching of metaphors differ in extension and suitability. I suppose that the metaphors ‘branching’ and ‘pruning’ as I used them above have clarified something I intended to transfer, but they expressed quite literally what happens by adding and removing connotations.

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[a] Feynman; Leighton; Sands(1963) *The Feynman lectures on physics I,II,III* (Menlo Park, California 1966, 1977) Addison-Wesley Publishing Company

An inextricable jungle

The words used in architectural discourses between designers and their critics do not add the connotations suitable in the language game I would like to play: the game of possibility. Forty[a] summarises some key words in the language game of the architectural discourse: character, context, design, flexibility, form, formal, function, history, memory, nature, order, simple, space, structure, transparency, truth, type, user. In his essays on any of these key words he cites famous architects and critics and he refers to crucial texts on architecture. They often speak in metaphors with something for everyone. It is striking how far the use of these words in this discipline deviate from the same words used in any other discipline. Even 'form', 'structure' and 'function' are used as metaphors with so many branches, that they have become meaningless. Each tree has become a jungle in itself. Changing words such as 'structure' and 'function' into 'system' and 'affordance' will not prevent the same jungle. They have to be pruned, not by language but initially by distinguishing direction and scale. Language does not have a North-arrow and a scale as drawings do. Time is its direction and its categories very often hide an implicit level of scale (and consequently a resolution). Conclusions about the form, the structure and the function of a chair are implicitly used in the next sentence to argue how to design a town. This may be useful as a metaphor, but concealing the scale of an argument causes serious mistakes. These confusions are so serious, that I distrust any text containing scale-sensitive categories without an explicit specification of their scale (unless it is absolutely clear by its context). It clarifies the relatively limited number of citations in this thesis.

The direction may be a lesser problem, because it is often given in a sentence with a subject, a verb and an object or target: 'I fell a tree', 'I go home'. If the action is represented by a verb, preceded by the actor and followed by the result, then it is a *function* from the actor into the result: result = f(actor). But, it contains a causal supposition. The direction may be projected in a temporal sequence, but it still raises confusions talking about spatial objects not supposing any *specific* direction or action. Design supposes conditions. A cause is a condition for something to happen, but a condition is not always a cause.

Direction

Suppose you agree with me that a ball is always convex, and we find one large enough to enter. You enter the ball and you conclude that we have made a mistake. "A ball is concave!" you shout to me from the inside. I disagree, and we have an argument at the entrance. We call a judge to decide whom of us is right. The judge is a wise man, and a well-respected authority in this field. After some minutes with a frown he has made his decision. "Perhaps", he says, "you are both right". He waits until this deep thought has calmed us down to be prepared for his final conclusion: "A ball is *undulating*: now convex, then concave". He walks away with a smile, leaving us in embarrassment. His 'now and then' solution is according to our experience in time, but 'undulating' does not agree with what both of us have seen. We decide to distrust our eyes and to accept the verbal wisdom of such a well-known authority. Science often has been advanced before by distrusting personal experience in favour of a verbal expression. In this case, however, it has moved us further away from reality than each of the verbally contradicting experiences did before. This does not only happen discussing a ball. It also happens discussing more abstract concepts such as 'function'. A dwelling has an inward function for its neighbourhood, but it has a different outward function for its residents. This direction-sensitivity is confusing if you do not recognise the substantial difference between both opposite or at least different concepts of inward or outward 'function'. And, it happens at any level of scale again.

[a] Forty(2000)*Words and Buildings A Vocabulary of Modern Architecture*(London)Thames & Hudson

Scale

Suppose, you walk through a street with buildings, and they are all different from each other. You turn the corner into the next street, also with buildings, each different from the other ones, and so on. After 20 minutes walking, you may conclude that every street is the same. None of them has a recognisable identity. The neighbourhood as a whole is homogeneous. What happened? Walking 100m you saw diversity, but after 300m you saw a homogeneous mixture. Diversity$_{100m}$ everywhere has caused a kind of homogeneity$_{300m}$. The buildings are different, but the streets would have been more different if their buildings would have had something *in common* per street. *What* they have in common in one street should of course be different from what they have in common in the other streets. Some equalities$_{100m}$ would enable differences$_{300m}$, if at least these *equalities are different*. The statement 'equalities are different' sounds as a contradiction if you do not distinguish levels of scale. I call this phenomenon 'scale paradox'. It is a spatial equivalent of Russel's paradox, of which 'I lie' is an example (if I lie I speak the truth, but if I speak the truth, then I lie). The solution is to distinguish the level of the expression from a meta-level *about* the expression. If you tell a lie and *after* telling that lie you would say 'I lied', then you would speak the truth *about* the lie. If the scale paradox applies to difference in general, it applies to any difference. The diversity of functions such as sleeping, cooking and cleaning afforded at home$_{10m}$, does not *diversify* the street, but it is *repeated* in the street$_{100m}$. To diversify functions in the street$_{100m}$ you may use other variables such as plantation, pavement and street furniture. Any level of scale may have its own most suitable variables to diversify the environment. These variables with values are eventually used as a legend of a drawing. Environmental variables, their values - eventually used as legend units - are the 'content' of environmental diversity.

Content

Any drawing has a legend. A legend (Latin for 'what has to be read') is the 'vocabulary' of the drawing. Some legend units are so generally used, that they are not specified in a separate legend. A line may indicate self-evidently a separation or a connection; red may indicate 'built-up', and green 'greenery'. The number of legend units in a drawing may vary between 3 and 80.[a] The vocabulary of a text is mainly much larger, but in a drawing the legend has three advantages not immediately present in a text. Any legend unit in a drawing directly represents a quantity, a general form and separate shapes. The quantity is represented by the length or surface it covers in the drawing, specified by every several length or surface. For example, the capacity of an urban plan can be checked counting the surface covered by the legend unit 'built-up'. The form is represented by the dispersion of a set of singular surfaces from one or more legend units in the drawing. You could call it the 'inward form'. The 'outward form', the shape, is readable from any coloured or circumscribed surface in a drawing separately. In this thesis, a primary question is: which legend units are possible at all? To answer this question, a category of legend units is named as a 'variable'. Built-up areas may have different building heights represented by different shades of red. These different shades, e.g. representing buildings of 0, 1, 2 …10 stories high are the possible values of the variable 'built-up'. The values a variable can contain are a set of legend units. I found approximately 150 design variables that could be applied at 6 different levels of scale, on average. If they have a different meaning at every level of scale, producing a different kind of diversity, then there are 900 variables. These variables count 3 values, on average. The possible vocabulary of spatial design then would count approximately 2700 'words', or legend units, to be dispersed in space.

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[a] Jong;Witberg(1993) *Stromend Stadsgewest, Legenda-analyse* **IN** Klaasen, I.T.; Witberg, M. *Het Stromende Stadsgewest derde Eo Wijers prijsvraag plananalyse* (Delft) Publicatiebureau Bouwkunde Delft http://team.bk.tudelft.nl/Publications/1993/legendaanalyse.doc

Form

If V values or legend units are dispersed at L locations in a drawing, then the number of possible alternatives is V^L. If you choose either red or green for every m^2 on a 20 x 20m = $400m^2$ lot, then the number of possible forms (2^{400}) is already larger than the number of atoms in the universe (i.e. a combinatoric explosion). A small part may be useful as proper designs, but that number will be still inconceivably large. A designer cannot handle such a multitude, evaluating their potential use to optimise the form. And, it will be even larger if you choose more than two legend units. Anyhow, the content (legend) is obviously not the only factor to determine environmental diversity by design. The same content can appear in an inconceivable multitude of forms. Apart from a chapter about diversity of content, there should be a chapter about the diversity of form. To cope with its possible multitude, I looked for a second order variable of 'form' starting with two legend units to be dispersed (to produce a 'form' and a background 'counter-form'). What could be its absolute value, the zero-point of form? I chose two extremes: total accumulation and total dispersion of a legend-unit. Any form is positioned somewhere in between, but which of both should be the zero-point from where you can measure its deviation? I chose total accumulation as a zero-point, always approaching a circle or a globe by closest packing. Any deviation from a circular shape is more dispersed and dispersion has no limit in an expanding universe. Total accumulation may be a black hole causing a problem for physics as its 'dark knowledge', but for us, a '0' perfectly represents the zero-point of form.
I did not manage to find a method to measure the deviations, but I made at least a start. Something else bothered me more: how to make the step from 'form' into possible 'function'. This thesis limits 'function' to workings for people. 'Function' introduces time again. Stability is a hidden supposition in the working of many things potentially useful for people. A completely unstable form mainly does not 'work'. A house dispersing as a cloud does not work, an evaporating computer or a liquidising hammer does not work either. What, then, keeps a form in good shape or condition? A set of connections and separations in different directions at different levels of scale stabilise a form. At a molecular level, they may appear as attracting and repulsing forces. At the level of a building they appear as stress- and pressure-resisting components, such as cables and columns, or as components resisting, directing or selectively allowing movements such as walls, doors and windows. At the level of a town, they may appear as an infrastructure of roads, cables, pipes and dikes.

Structure

In this thesis 'structure' is defined as 'a set of connections and separations stabilising a form'. The usual definition 'the way parts form a whole' applies to any composition with components still not necessarily connected or separated to stabilise them. The real structure may be used as a metaphor to explain the perception of a composition as 'coherent' (harmonious), 'connecting' (relating) some components, while others are 'separated' (contrasting). But, that kind of connotation should be pruned if you want to position structure between form and function. It is even worse if 'structure' is confused with 'order' as a kind of regularity observed in a composition, a form with components arranged in a repetitive *pattern*. You may then suspect a 'structure' keeping similar components in their place, but it is often the result of a process obeying the laws of entropy, *dis*order at an other level of scale. The closest packing of oranges in a box forced by gravity or the regular pattern of soap bubbles forced by dispersing and balancing surface tensions causes beautifully ordered hexagonal patterns, but there are no connections and separations stabilising this pattern. It is the result of a process, far from equilibrium. Shake a box of cigars in a chaotic position and they will order themselves in such a way that you can close the box. 'Self-organisation' has nothing to do with organisation, the diversification of organs purposefully specialised and accordingly separated and selectively connected in an organism or organisation. Membranes and fibres *between* these organs take their own place as connections and separations. Structura is Latin for brickwork: the separating bricks are connected by layers of cement, taking their own space to stabilise the bricks.

Functional diversification

Discussions concerning the ‘meaning’ of forms reveal that, even if I had succeeded in providing an exhaustive description of morphological and structural diversification (which I did not), this description would nonetheless fail to explain how the same structure with the same content and form may have different meanings and uses: *functions*. This made it necessary to write a fourth section (Chapter 6) about ‘functional diversification’. The same thing (having the same content, form and structure) may have different functions for people, animals, plants or constructions. A wooden beam may have one function (working) in a construction, a different function for fungi, insects or birds, or it could be used as fuel by people. Functions for people, however, are different from those for constructions, plants and animals. Moreover, the term ‘function’ itself is ambiguous. It was necessary to explain this properly before I could arrive at the functional diversification relevant for urban design in Chapter 6. Even within this restriction, however, there are countless ‘functions’.
How can we understand functional diversification if we can distinguish so many functions?

Functions for humans

Chapter 6 is restricted to functions for humans and society within an urban environment. The well-known distinction of four urban functions (i.e. residential, employment, recreation and traffic) is apparently based on a supposed mutual nuisance. The Congrès International d'Architecture Moderne (CIAM) asserted the necessity of spatial separation between these functions in order to avoid nuisance. This approach, however, results in separations that exceed the reach of the nuisance. Other distinctions (e.g. administrative, cultural and economic functions) can be subdivided more systematically. In 1978, one city in the Netherlands (The Hague) had a primarily governmental function, while others (e.g. Amsterdam and Rotterdam) primarily served cultural or economic functions.
The latter distinction appeared useful for describing the process of functional diversification. Mediaeval towns also had administrative (castles, palaces), cultural (churches, cloisters, schools) and economic functions (markets, shops, dwellings, small traditional trade businesses), albeit at a smaller level of scale. At that time, administrative functions could be further diversified into functions for legislative, legal and executive facilities, reflected within the city through town halls, courts of law, governmental services, police stations, prisons, barracks and military training grounds. Cultural functions could be further diversified into the categories of religion or ideology, art and science, childrearing and education, reflected within the city through churches, monuments, signs, museums, institutes, libraries, socio-cultural facilities and schools. Economic functions could be further diversified into production, exchange and consumption, reflected within the city through firms, banks, offices, distribution points, shops, infrastructure, living, health service and recreation. Chapter 6 recognises this approach as ‘inward’ and its adds a complementary ‘outward’ approach.

Difference

Empirical science collects facts to find *equalities* called generalised ‘knowledge’. Design applies many existent components and this requires generalised knowledge. But the core of design is to make non-existent objects, *different* from what exists. How to make them different from what we know or expect as probable? The number of possibilities is inconceivable. A design cannot be a conscious choice between unimaginably many possibilities. If you are not even aware of them, then you are inclined to choose traditional solutions. But, the problems we face are not traditional. We have to make a difference. The world population doubles twice in a life time; the environment changes; the context changes. The diversity of possible futures is larger than history, larger than the sum of all probable futures together and consequently larger than anyone can imagine. We have to cope with this diversity, but we can’t. We have to cope with difference, but we are educated in equality, equations and generalisations. ‘Different’ is often concerned as the opposite of ‘equal’, but that is a mistake. You cannot recognise a difference if things are equal, but you can

recognise an equality if things are different. Equality is a special case of difference. An object can be more or less different from a second object, but not more or less equal. If objects differ less than the least difference you can observe or imagine, then you *call* them equal. Equality is the zero-point of difference. It can be approached, but not reached, otherwise the objects you compare should be the same thing. And, the expressions 'A = A' or 'A = not A' only make sense if A can change during the reading passing the '=' sign. In that case they express continuity or change. Change thus is also a special case of difference. It is the difference between what you see and what you remember. Thus, continuity is consequently the zero-point of change. It can be approached, but not reached, because a memory is something else than an actual impression. According to Plato, Herakleitos would have said: "Anything changes". But I am inclined to say: "Anything differs". Without difference nothing can be observed or realised; without the concept of difference nothing can be chosen or thought. Distinction is the very beginning of imagination and thought. If equality is a special case of difference, if probability is a special case of possibility, then empirical science may be a special case of design. In the field of empirical science and education, this awareness increases, but in the field of design science and education, it surprisingly decreases. You cannot learn to create improbable possibilities by probability calculations. Evidence-based design is a dead-end street. It narrows down your capacity to imagine possibilities. This thesis aims to widen it.

Sets

A category or set supposes an outward *difference* to imagine the inward *equality* of its elements. But, the definition of a set according to Cantor[a] does not refer to this difference. Instead, it requires the definition of a common characteristic of its elements to assure some inward equality. The definition of this characteristic, however, necessarily uses words. Words themselves are categories or sets. To define subsequently these words, you will need other words. And so on. But, to refer to the outward difference instead, would require one to point out every object that is outside the set separately, using the word 'not'. Distinction is the very beginning of a vocabulary, but the distinction itself does not have a name. The *objects* that should be distinguished have names. Verbal language requires a subject and an object to explain the difference: "This differs from that". The difference *between* this and that is nota bene represented by a verb! A drawing does not have to translate a spatial difference into a change. A boundary between red and green self-evidently explains the difference. If you ask somebody "Which colour is the boundary?", then there is no answer. Designers *start* drawing boundaries, even if they still do not have any idea what exists at both edges. They study *possibilities*. It obviously cannot be done sufficiently by language. There are many objects, but there are inconceivably much more *differences* between objects. To study possibility requires the designer to cope with that diversity, and that is what we unlearned at school. This thesis aims to relearn it.

Kinds of difference

There is still a paradox I cannot solve: the expression 'kinds of difference'. I need it in this thesis, but it is a contradiction. There are different differences: differences in content, form, structure, function or intention. Content is a primary kind of difference. Difference of form is a second order of difference: the difference of dispersions in space of some content. Let me use Δ for 'difference of' to be not too boring. Δstructure is a third order of difference: the Δsets of connections and separations stabilising the form. Δfunction is a fourth order of difference: the Δuses of structures by humans. Δintention is the last order of difference: the Δbalances between functional needs and possibilities. Using the concept 'kind of differences' supposes an 'equality of differences'. What, then is the difference silently supposed *between* these sets of difference? I do not know. I simply trust the boundaries set by the young man.

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[a] Cantor(1895)Beiträge zur Begründung der transfiniten Mengenlehre(Mathematische Annalen)1100 46 4 p481-512 Springer http://gdz.sub.uni-goettingen.de/dms/load/img/?PPN=PPN235181684_0046&DMDID=DMDLOG_0044

Reading this thesis

The chapters of this thesis are written in a conditional sequence. The next supposes the previous, but you may read them separately. For practical purposes, you may jump to Chapter 3 on page 109, skipping the social and scientific justifications of Chapters 1 and 2. Every chapter is subdivided into sections and short paragraphs, with a title representing its content. It enables you to jump into paragraphs of interest. The thesis ends with an extensive index of terms, concepts and names, composed by syntactic key words (explained on page 274 and onwards). Spaces are omitted if they are not necessary.
If the North direction of a map or plan is not indicated by 'N', then the top of the image is the North direction. The scale of maps and plans is indicated by a circle with a radius R (not a diameter) given in the text accompanying the figure. In other parts of the text, the scale factor 'R' is defined as the 'nominal radius' of the area to be studied. Its value can be one of the set {1, 3, 10m….300, 10 000km} indicating the order of size of a length, a surface or a volume. The values are 'nominal', because 'R = 3m' may be interpreted as ranging between 1 and 10m (see *Fig. 17* on page 52). 'r' indicates a similar nominal radius of a *component* or the *smallest grain*. In a similar way P and M are used for polarities and mesh-widths in networks. If '⇓' is used, then 'y ⇓ x' means 'y supposes x' or 'x is a practical condition for the possibility of y'. 'Condition', thus, is not used in a logical, but in a practical sense.

References

References are given both as footnotes at the referring page and in the list of background literature on page 311. The in-text indicators of the footnotes are given at the end of a sentence if they concern the sentence as a whole and within the sentence if they concern a part of the sentence. Within the first pair of brackets of a reference, the year of the first publication is given. The second pair of brackets contains the place of the publishing and eventually a year of publication if the reference refers to a later edition, or it contains the title of a journal. If the second pair of brackets contains the title of a journal, then a four digit number after the last bracket indicates the month and the day of publication, eventually followed by a space, the volume, the issue and the first page number divided by spaces. This format enables computerised recognition of the reference data.

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Afterword

Dear readers, wait a minute. The angry young man attempts to take over my keyboard.

> *Dear old man, where are our ideals to change the world? Did you forget our idols, Chris van Leeuwen and Aldo van Eyck, who both sought the potential boundaries of space in order to produce differences? Did you forget their lectures and those of Carel Weeber, Frans Maas, Niels Luning Prak? Did you forget Jos Louwe and the 100 propositions of Sharawagi? Did you forget Job Tarenskeen's innate design skills (though he exchanged space for music), Pieter Schrijnen's social involvement, Joost Schrijnen's drive for practical realisation, Evert Croonen's humorous putting things in perspective, Peter Paul van Loon's rational and systematic approach, Mick Eekhout's visionary inventions? Did you forget Robbert Jongepier teaching us the first steps of design and proper handwriting (at last), the verbally gifted design teacher Leo Tummers, our engaging graduate mentor Peter Pennink, the geographers Chris van Paassen and Rob van Engelsdorp Gastelaars giving access to the humanities at the other universities, the lucid researcher Dirk de Jonge as the Socratic teacher between the rules unravelling our false suppositions, the sociologists Cornelis Saal and Jan Berting, convincing us that social understanding is crucial to change anything in the world? Where is this all in your thesis? You skipped nearly everything about the sociological basis of our profession: my beautiful functional distinctions, my psychological analyses, my overview of the humanities, the philosophical inspiration of Wim van Dooren, the anarchist. You have become a technocrat! Did you forget the national office for spatial planning RPD, the inspiring environment with Eo Wijers, Jan van Donselaar, Götz Nassuth, Peter Dauvellier, Everhart Reckman? There I wrote my thesis and there I am now writing its follow-up, 'Applied study on environmental diversification'. Wait and see, no more theory! Application, old man, application! We are going to clean up the nation with Peter Dauvellier's Global Ecological Model and my brand new study. We will involve all the people, we will convince them with excellent plans. What is your plan, what did you realise, what do you expect to gain with another thesis so theoretical, so technical?*

Dear readers, thank you for waiting. The angry young man is gone. He is jealous of my thesis, and he is not very honest. He is not so eager to show applications, but his employers and the people he mentioned ask for direct solutions. He wants to please them, because he loves them. He knows, however, that the box cannot be closed if you do not straighten the bottom stones, and everybody brings new stones. There are too many for his box, and he regularly retires for long periods in his room full of stones with his magic box. Nobody knows what he is doing there, and he is unable to explain. He has to choose, but he cannot choose due to a lack of experience. He does not dare to refuse the stones that look so precious. Let me now confidentially make a prognosis of what will be his future.

Years of practice

His 'Applied study on environmental diversification' will become a failure. Nobody will read its extended elaborations and its ugly pictures about the stones he brought into the field in order to build the regional structures that his employers expect. In a bureau for urban design in the North of the country, where he will be employed after the RPD, they will laugh about his box and his impressive PhD title (so unusual in the field of design), when his first design appears even not to contain enough parking places per dwelling. He will work too slow for the pace of the company. Intending to improve his design, he will see the contours of his unfinished plan (stripped by financial experts) already laid out with pickets in the field when he passes the area in the train next morning. The bureau will go bankrupt and he will start his own bureau named MESO in order to find the right middle between theory and

application. It will exist approximately 20 years, producing very diverse proposals and studies (e.g. regional energy plans, extensive wind tunnel experiments with TNO[a], future scenarios and an 'image quality plan' for the Amsterdam district 'De Baarsjes', an important break-through in his development).

Back into ecology

In the mean time - to his surprise - he will be invited to apply for the Ecology Chair to succeed Chris van Leeuwen in the Faculty of Architecture of the University of Technology in Delft. From more than 100 candidates he will be chosen, even though he pretends not to know enough about ecology. It will last 5 years before the Faculty can finance a new Chair. He will use this period to study authoritative handbooks of ecology, discovering that *nobody* knows enough about ecology. He will suspect that there is something missing in the common scientific method. He will realise that the heritage of van Leeuwen *generates* the observed diversity instead of *reducing* it, as is usual in common *generalising* scientific thought. Is there something wrong with empirical science itself, when it is confronted with context-sensitive diversity, possibility and design? And if so, what is it? Anything that is able to be generalised seems to be generalised already; the unique, context-sensitive issues remain. This methodological question will bother him for years to come.

The academic sinus

When he enters the University in 1986, he will meet his professors from 1976 who will now ask to be addressed by their forename. The Faculty will be exactly the same Faculty that he left ten years before, except it will now have been increased in size. He will learn the peculiarities of management, for example, the rule to make a U-turn about every 4 years. Every new Dean will change everything when confronted with the failures of his[b] predecessor. He will arrive at the point where the predecessor of his predecessor had arrived already 8 years before, a context that not many people will remember anyhow. Therefore, nothing changes in the long term. The young man will discover this regular fluctuation only after at least 12 years of involvement as one of the predictable sinuses of management. This will reduce his initial stress, resulting in a happy rest of his academic life.

The first U-turn

Here begins my own story. In the first period as a part time professor I attempted to introduce the box of the young man writing lecture papers and computer programs, but then, fortunately, the first U-turn emerged in 1990. My courses and lectures were abandoned, in order to obtain a brand new start with 'problem based learning', so I could learn from the new study programme. This case based educational method had been a great success in the Medical Faculty of the University of Maastricht, and their educational professionals came to teach us the method to reform the system that our Faculty had already practiced for decades in its design studios. The Dean asked the most experienced professor (i.e. Carel Weeber) to organise the first year of the brand new education method with the youngest professor at the time (i.e. me). The resigning fellow teachers taught me the educational sinus following the one of management. If you do not succeed in obtaining sufficient commissioned hours in education, then you will have enough time to participate in the boards that *organise* the new education. After some time, it will result in an increasing number of commissioned hours for your own course, filling the hours of the abandoned courses of the others. It gives, however, the others time enough to succeed you (being too busy) in the educational boards, where they prepare the next U-turn.

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[a] The Dutch national institution for applied technical studies.

[b] This masculine personal pronoun is chosen because all Deans were masculine, except the last, announcing the revolutionary intention *not* to change everything.

Two cupboards

By collecting new literature and writing new lecture papers and computer programs, and being inspired by my parallel MESO-work, I was wise enough to store the old course material in a cupboard. Let me name it cupboard A. The same occurred after the next U-turn. As usual, after 4 years, I was asked whether I could make a new course for a brand new education programme. I stored the abandoned courses with their literature, sheets, lecture papers, test questions, exercises, assignments and computer programs in cupboard B. I opened cupboard A, which could be adapted easily into a course with the demanded title, because the next Dean had finally arrived where his predecessor began. Thus, it takes 12 years to become acquainted with the AUBUA-system, in order to make substantial progress in improving the subjects of A *and* B. I must, however, report one remarkable exception on the discontinuity of educational titles and contents of lectures. From the beginning, I became involved in a lecture series 'Environmental Impact Analysis' at the Faculty of Civil Engineering, coordinated by Peter van Eck. He managed to safeguard the continuity of this course through all of the 25 years I was employed at the University. It was the only course I witnessed that lasted so long, and the yearly adaptations and improvements of the lectures and the exercises resulted in the best lectures of my career. I was very grateful to Peter that my last lecture at the University could be given in his course at the Faculty of Civil Engineering.

Different titles for the same content

I now understood the background of the irritations of the angry young man as a student, refusing to attend courses of different professors telling the same thing, while the titles of the courses were different. With a group of students called 'Sharawagi', he had made lecture papers from these similar lectures. Sharawagi then sent copies to the other professors, in order to inform them about the overlaps. I now understood that the professors did not produce lecture papers concerning the detailed content of their course, because it had to be changed so often. They simply could restrict themselves to change the title of the course, continuing to use the same sheets or powerpoints. Managers like appealing titles to sell their success. The presentation sells, not the content.

Overlapping shadows of doing

The consequence has been, however, that nobody knew what content hided behind the promising titles, except the students. The students wisely did not inform the boards about the extensive overlaps, because it is convenient to pass exams with similar questions. Dean Jürgen Rosemann once assigned MESO to study the contents of the first two years of the Faculty in more detail than just titles. This study unveiled that the Villa Savoye by Le Corbusier was discussed and tested 17 times in different courses. The required readings amounted to more than 150 books, of which little could be recognised in the tests. Instead of studying them, the students could better study the tests of previous courses, because the same questions returned, alternating in a predictable way. In design oriented education, the studios as a kind of learning by doing education, are more appreciated than lectures and empirical sources that partially deepen subjects. Science and the humanities support little in the *making* of a context-sensitive spatial design, requiring simultaneous decisions about content, form and structure, estimating their possible functions every second.

NNAO

This takes me back into the methodological question already bothering the young man. What kinds of studies and research are required for spatial design? The scientific board for government policy (WRR) had published two reports on national *policy* directed scenarios in 1983.[a] The WRR reports, however, also distinguished the modes of reason in policy, empirical research and design, which the young man distinguished in his thesis (further elaborated in this thesis, see *Fig. 2*). In 1985, Dirk Frieling and Kees Rijnboutt subsequently initiated a project on four national *design* directed scenarios for 2050: 'the Netherlands now as a design' (NNAO). Four scenarios were made: a 'Zorgvuldig', 'Dynamisch', 'Kritisch', and an 'Ontspannen' scenario (i.e. a 'Meticulous', 'Dynamic', 'Critical' and 'Relaxed' scenario, according to the programmes of Christian Democratic, Liberal and Socialistic parties in the Netherlands of the time, and an own optimistic 'Technocratic' NNAO view). The scenarios were made by four different research bureaus. The resulting programmes were elaborated into a design by four different design bureaus. MESO made the Relaxed scenario, calculated different effects of the scenarios, checked the designs upon the programme resulting from each scenario, and made simple computer programs in order to be able to do so. Many reports and publications appeared[b], and the project culminated in a large NNAO-exhibition in Amsterdam.

Momentum

With 8 Urbanism and 4 Industrial Design students of the University of Delft, and with Alexander Kyrkos as the leading designer and C-programmer, I developed a computer game 'Momentum' for NNAO. This computer game enabled anybody to design her or his own scenario.[c] At any design intervention, it reported which of the four political parties would be most satisfied, showing their representatives as laughing or crying faces ('emoticons' as you would name them now). I clearly remember the evening with one of the students, Wient Mulder, on which we suddenly managed to develop an algorithm to let them laugh, cry or something in between. This algorithm was based on a study by the University of Amsterdam, which was focused on the spatial suppositions of political programmes since WWII. At the exhibition, four politicians played the game simultaneously on stage, declaring to agree fully with the computerised emoticons they represented. We apparently had interpreted their suppositions correctly.

Suppositions of imagination

This NNAO experience changed the box of the young man into the idea of a successive conditional construction of suppositions. Any cause is a condition for something to happen, but not every condition is also a cause. It clarified the relations between probability, possibility and desirability, as the territories of empirical research, design study and policy. I managed to *draw* them for NNAO as the including and overlapping sets of *Fig. 2*, but I underestimated the resistance against this obvious scheme. Authorities defend their territories as the young man already described in an essay on request of Wim van Dooren.[d] The conditional sequence appeared to be applicable in many areas: the modes of reasoning (probable, possible, desirable) the orders of difference (content, form, structure, function,

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[a] WRR(1981) *Beleidsgerichte toekomstverkenningen* (Den Haag) Wetenschappelijke Raad voor het Regeringsbeleid
WRR(1983) *Beleidsgerichte toekomstverkenning. Deel 2: Een verruiming van perspectief* (Den Haag) Wetenschappelijke Raad voor het Regeringsbeleid

[b] NNAO(1986) *Ontspannen scenario* (Den Haag) MESO
NNAO(1987) *Nieuw Nederland 2050 deel I achtergronden* (Den Haag) SDU
NNAO(1987) *Nieuw Nederland 2050 deel II beeldverhalen* (Den Haag) SDU
NNAO(1989) *Nieuw Nederland, Nu Nijmegen & Arnhem Ontwerpen* (Den Haag) SDU
NNAO(1989) *Nieuw Nederland, proeve van een investeringsstrategie* (Den Haag) SDU

[c] Jong(1985) *Programma NNAO scenario* (Den Haag) Stichting Meso and Sociaal-geografisch instituut UvA
Jong(1986) *Energiebijlage Programma NNAO scenario Bijlage 3* (Den Haag) Stichting Meso and Sociaal-geografisch instituut UvA
Jong;Kyrkos;Reijden;Smink(1989) *Staat van Momentum Fase C. Workshop Momentum (Delft*) Faculteit Bouwkunde TUD

[d] Jong(1978) *Autoriteit en territorium* (De As, anarcho-socialisties tijdschrift) zesde jaargang, nummer 31

intention), and the layers of function (space, ecology, technology, economy, culture, management). In 1992, I published an attempt to unravel an all-embracing fundamental sequence of conditions as suppositions of imagination.[a] This elaboration of the young man's fascination on conditional thinking, instead of causal thinking, may be my greatest achievement, but its nearly mathematical strictness still contained gaps. The philosophy professors of our University, Peter Kroes and Marc de Vries, refused my attempt to elaborate it as a thesis. Marc de Vries was most clear about the reason. He missed practical examples as an empirical foundation. The current thesis may provide some applications before I can resume this even more fundamental work.

Suppositions of the audience

Before I became involved in the NNAO-project, I had some experience in Basic computer programming. Designing the complex computer game Momentum in C-language, however, made me even more aware about the necessity of conditional thinking while designing. A computer is really a blank slate, a tabula rasa. If you do not inform the machine of *all* suppositions or conditions, it immediately reacts with 'error'. Many hours can pass before you find the missing line or sign in the source code. You are not aware of all necessary suppositions, so self-evident in human communication. The experience of repeatedly stagnating computer programs made me conscious of the possibly of missing lines while teaching students. A human audience will, however, not react with 'error'. You thus never know if it shares all the suppositions that are required to interpret your words adequately.

Interest-based suppositions

Making and evaluating the future scenarios, I also realised how many hidden suppositions there are. There are numerous assumptions about the physical, ecological, technical, economic, cultural and managerial conditions, which are usually taken for granted as ceteris paribus suppositions. They determine whether a scenario is possible at all, but their continuation in time must be questioned. Changing any of them may change the scenario as a whole. For example, for the Relaxed NNAO Scenario, I assumed that fusion power would become the future energy source, but this soon appeared to be a bold supposition, as Kees Duijvestein already mentioned with some good-natured scoffing. Later I replaced the fusion-assumption into the supposition that solar power would become the final energy-source. The first suggests a centralised, the second a decentralised production with many consequences for any scenario. Both suggest future energy-abundance. Assuming an abundant availability of energy, however, undermined the usual advice of economical energy-use: thermal insulation, wind energy and so on. I attempted to refute the common supposition of future energy scarcity through a simple calculation, but this did not convince the professionals. 'Algebra is also an opinion'. It undermined the common suppositions on which the livelihood of current environmental professionals are based. Some truths or technological expectations may be rejected if they endanger short term human interests.

The paradox of planned innovation

Fascinated by interest-based suppositions, I attempted to doubt *any* supposition, and I discovered many common suppositions that I did not share. The increasing commercialisation of science destroys its core: doubt. You cannot sell doubt. People pay for certainty. Even if you can falsify its foundations, the opinion of the majority offers more certainty. Marketing is based on statistics, but evolution rewards rare exceptions. Innovation cannot be forced through a research programme, but you cannot obtain funding without a research programme either. I was involved in, or witnessed the writing of many research programmes on the level of the University, the Faculty, its Department and my Chair, but I never witnessed any innovative result. Innovation requires skipping at least one common supposition, but a research programme is based on the consensus of the committee writing it. It is a compromise, resulting in an average 'feeling' of old, wise men, neglecting the

[a] Jong(1992) *Kleine methodologie voor ontwerpend onderzoek* (Meppel) Boom

exceptions. An ‘innovation programme’, thus, is a paradox in itself. If innovation can be programmed, it cannot be innovative.

Technology as a driving force

Technological innovations, however, changed the world more radically than anything else. The wheel, the iron, the art of printing, the steam engine, electricity and the transistor changed economies, cultures and the division of political power, not the other way around. Scenarios are still made assuming that a government, a culture or an economy are the driving forces of technological innovation. Wilkinson[a], however, argues that progress is the result of changing conditions, ecological adaptation, and poverty. This appealed to my conditional thinking. I did not deny some positive *causal* effect of economy, culture (including the subculture of empirical research) or government on innovation, but I could not imagine this effect outside the physical context, without the boundary conditions of ecology (including resources, demography *and* available devices, technology).

The disadvantage of politeness

Innovation may require disobedience, rejecting common suppositions, even if they are profitable for current managers, professionals, industries and traders. In my opinion, my colleague professors were too obedient, too friendly with the managers that gradually took over their organisational tasks, rating their production instead of their potential innovation. The simple suppositions of management can be astonishing. Innovation may require many failures first, and success may appear to be false at last. ‘Success’ then will be forgotten soon. In my opinion, my colleague professors were also too friendly to each other, hesitating to criticize. Part time professors may meet each other in practice, and faultfinders are not popular in a production team. A University, however, is not a mass production team. It is an innovation team, requiring difference and mutual critique. Its product is heterogeneous. Students are different, full of different potentials, and consequently heterogeneous as a graduated ‘product’ of personal academic education. The products of academic study should make a difference, they should be risky, improbable, with often unexpected side effects, but I had to conclude they were not.

A second sinus

The producers apparently attempted to fulfil expectations, producing fashionable short-term solutions, which will create new problems in the future. Studying these disappointing products, I suspected a scientific sinus of about 30 years. I recognised the attempts of thirty years ago, by putting the repetitions into perspective. I realised that any research or study requires a long term scenario, in order to make its suppositions explicit, and some historical awareness in order to avoid repeating mistakes. I politely started to criticize the lectures and the papers of my colleagues, observing the reactions with scientific interest. The reaction was mainly no reaction, sometimes irritation, and it was rarely characterised by a spirit of appreciation, curiosity, counter-arguments and counter-critique. This became my selection instrument for ´true academic friends´. I was no longer invited for managerial tasks, I did not receive hopelessly useless emails that needed to be answered, and this saved time. My most productive academic period began.

Dirk Frieling

In the nineties, I temporarily occupied several chairs of the department of Urbanism at our Faculty of Architecture, in order to keep them occupied until a proper successor could be found. I suggested Dirk Frieling (the ‘Founding Father’ and developer of the Dutch new town Almere) to join our department as a professor, and he did. He had commissioned MESO with assignments for NNAO through very precise letters, exactly leaving open what had to be left open. The results were returned with accurate remarks in the margins and sometimes devastating, but always distant criticism, in a beautiful handwriting. He managed to put your

[a] Wilkinson(1973) *Poverty and progress* (London) Methuen

efforts in a wider, physical and social, nearly philosophical perspective, having a good nose for the context of the time. An avalanche of initiatives stirred up the Urbanism department and the Faculty immediately after his arrival. I witnessed how he convinced the right sponsors, through his surprising schemes that were sketched with a sure hand at the table of the right restaurant, as if these schemes put *their* ideas in a wider and promising perspective. Once the funding had been arranged, nearly everyone in the department became involved with challenging commissions that they could not refuse. I received a perfectly hand written note in the style I knew so well, containing a budget and the request to compare some designs for the Randstad in the framework of a vague project named 'The Metropolitan Debate'. Debate! But, how to analyse this heterogeneous set of plans which varied from vague into very precise, with different population capacities, legends, contents, forms, structures, functions and intentions? He knew how to challenge me. Graphic designer Ellen Ali Cohen (I knew her from my 7th year; we played in the same street) made an up to date and very precise map of the Netherlands. We married, but this had more reasons than the map. With Alexander Boelen, my PhD candidate, I discussed the method and he prepared the overlays. It is a great pity that he did not finish his PhD. Without intermediate reports through the years of his employment, he finally offered to me an extensive concept thesis, but he could not explain the method otherwise than naming it 'research by design' at one page. It was a low point in my career to realise that I could not explain it properly either. Only seven years later (editing Ways to Study with Theo van der Voordt), I managed to give it the right place in relation to empirical research. Nevertheless, the current project was the very beginning of a method, and Alexander contributed a substantial part to it. Apparently surprised by our first report[a], concerning the comparison of four plans, Dirk Frieling reacted sparingly: 'It may work. Here are some other plans.'.[b]

The Metropolitan Debate

The Metropolitan Debate appeared to be the forerunner of the still existing society of large municipalities named 'Vereniging Deltametropool'. Many studios and workshops followed in different parts of the country, which were meticulously prepared by Frieling's extensive questionnaires. The questions were so challenging, that the response from the nearly 1000 participants from all parts of the country and from most diverse professional backgrounds was higher than anyone expected. Within a week, every participant received a statistically elaborated summary of the answers and a new questionnaire, which forced the participants to make their position gradually more explicit. After four questionnaires, the workshop could start with well-prepared participants. You could choose a project from the list of Jan Brouwer, a location, and try to realise it there. Then you could attempt to obtain administrative approval at one table and financial funding at another table, based on a scientific impact analysis at still another table. If you succeeded, than your project was put on a large map, while four politicians simultaneously defended the maps based on the scenario of their own party at the remaining side of the room. Looking at the map with projects, they could ask for a referendum, which eventually skipped your project. The game of negotiations was so exhausting, that I sometimes left halfway, but Dirk was indefatigable. The day ended discussing the resulting map: 'Is this the country you want to live in?'. Frielings speeches were challenging, and I once exclaimed 'What a nonsense!', explaining why I disagreed. He answered as a true academic friend: "Taeke may be right in this respect, but …", and subsequently he summarised where I was definitely wrong.

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[a] Jong;Boelen;Ali Cohen(1995) Analyse van 4 ontwerpen voor de Randstad(Zoetermeer)MESO

[b] Jong;Dieters;Boelen(1996) Voorlopige morfologische analyse van 12 plannen voor de Randstad(Zoetermeer)MESO
Jong;Achterberg(1996) 25 varianten voor 1mln inwoners (Zoetermeer)MESO

Comparing designs

I could not fulfil Frieling's request to make a computer program that reported the regional impacts of any arbitrary project, based on empirical evidence. The context-sensitivity of spatial plans makes every project an exception to the rule. Generalised 'knowledge', with the *same* (ceteris paribus) suppositions, but in *different* contexts, may harm local potentialities. However, the comparison of *different* designs in the *same* context, with the same suppositions, could be useful. With the experience of NNAO and the Metropolitan Debate, I could accept a commission from the municipality of Almere, to compare the ecological effects of four designs concerning an extension of 50 000 inhabitants. My experience in ecology, however, had taught me that strictly empirical research is mainly concerned with the impact on the chance of survival of one species, and that the impact on communities or ecosystems always must be based on suppositions about their 'value'. This value, then, must be compared with the value of human projects. This brought me to the solution to take *rareness* and *replaceability* in order to evaluate both ecosystems and human projects. Rareness could be expressed in the distance in kilometres until the next example can be found, and replaceability could be expressed in the number of years required to realise the same kind of project or to develop a similar ecosystem.[a] This measures allowed me to put the ecological communities *and* human projects in the same graph depicting their position in spatial rarity and temporal replaceability.

A speech

Comparing designs may offer a bridge into empirical research, but this still does not solve the question: what role can empirical research play in the *making* of a design, other than preparing its programme beforehand, and evaluating its result afterwards. In 1995, I had the honour to pronounce the annual 'Diesrede', the speech on the occasion of the anniversary of the University (Dies natalis), which represents the state of the art in one of the Faculties. Every year, another Faculty has the honour to do give the speech, and this time it was the Faculty of Architecture's turn. Our Dean at the time, Jürgen Rosemann, decided that I had to give the speech. In one of the previous U-turns, our Faculty had dismissed its gradually isolated institutions for empirical research on architecture, urbanism and housing. The design chairs argued that the studies of these institutions were useless for design, and they wanted to develop their own ways to study.

A University audience

I knew the doubts of the other faculties concerning the scientific competence of our Faculty. In the University, the debate concerning our competence emerges once about every 10 years, and always results in the obligation to implement a substantial mathematical course in the education of the Faculty. With Jan Aarts from the Faculty of Applied Mathematics, I had developed such a course, but this time-consuming component of the education disappeared by the next U-turn. Jan dealt with his disappointment writing a book on geometry full of linear matrix algebra[b], convincing me of the difference with architectural geometry. Jürgen thought that I could convince the university community of our scientific value beyond mathematics. I did not always agree with Jürgen, but he appeared to be a true academic friend, and he gave me total freedom to determine the content of my speech. It was entitled 'Systematic transformations in the drawn design and their effect'.[c]

Transformations in drawings

My father, a nuclear physicist and retired professor of fine mechanics from the Faculty of Mechanical Engineering at our University, was proud but worried. I inherited his professor's robe, but he knew the young man with his bold statements. He offered me the opportunity to practice with a small audience, and gently gave advice as a father does. He took care of my

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[a] Jong(2001) *Ecologische toetsing van drie visies op Almere Pampus* (Zoetermeer) MESO
[b] Aarts(2000) *Meetkunde. Facetten van de planimetrie en stereometrie* (Utrecht) Epsilon Uitgaven
[c] Jong(1995) *Systematische transformaties in het getekende ontwerp en hun effect* (Delft) Diesrede Technische Universiteit

presentation and reproduced my sheets. The content, however, was mine: designing is continuously adding dots, lines, surfaces or volumes to a drawing, comparing the result with the previous stage. Any transformation of your design has an effect that can be evaluated. You can distinguish different kinds of transformations systematically. Their effects may be suitable to be generalised. I showed examples produced by our Faculty at many levels of scale. It was a success, and my father was reassured. Jürgen could now ask for his university funds without shame.

Methodology

However, I was not so reassured myself. Is designing nothing more than drawing and comparing drawings, 'precedent analysis'? What about possibility-search? Later on, another Dean, Hans Beunderman, who was apparently urged by Dirk Frieling, commissioned me to develop a methodology book for the Faculty, concerning design-related research and study. He also commissioned me to make a computerised database of graduate designs. The computer program was overtaken by Google, but the book was used in every semester of the education until the next U-turn. This project became a success, thanks to my co-editor Theo van der Voordt. Theo is a meticulous, irreproachable empirical researcher, and I could quarrel with him as a true academic friend. He made the book acceptible for both designers *and* researchers in the Faculty, a unique achievement. It was entitled 'Ways to study and research urban, architectural and technical design'.[a] The word 'study' was intended to include design itself.

Ways to Study

Based on our request, fifty authors from our Faculty wrote a chapter for the book, explaining how they executed their research and study. Herman Hertzberger agreed to include two of the most impressive chapters concerning how to design. Even Hugo Priemus promised to write a chapter about strictly empirical research as the only way into scientific progress. Hugo Priemus was our former Dean, and director of the research institute that became the national authority on housing, after its separation from our Faculty. He was well-known from television in times of real estate crises, and was a confirmed empirical researcher. He was, however, so busy, that I proposed to write it for him as a clerk does for the President. "I know exactly what you want to write" I boasted. He smiled. He knew how much our opinions about research and study differed, and how little I had published compared to his astonishing production. He handed me a pile of authoritative methodology books, and I wrote his chapter. "Is this what you wanted to write?" He hesitated with a frown. "…Yes". "Then sign for it". "…How could I? You wrote it. You must be named as the author". "Me? Never! I do not sign for such nonsense!". I immediately felt regret for this bold statement, but Hugo smiled. "Let us both sign for it." This was a great honour for me, but I hesitated. "In that case, I have to add some remarks." Hugo agreed with the result and to the great surprise of Theo, our book included a chapter written by two authors more opposed to each other than anyone in the Faculty could imagine.

Doctorate ceremonies

Some years after my Diesrede, I was invited as a member of the University Board for Doctorates. I accepted the position as a great honour. It included regular meetings with the Rector Magnificus, the Deans of the other Faculties, and the obligation to chair a part of the promotion ceremonies on behalf of the Rector. In approximately ten years, I chaired some 400 ceremonies, mainly and intentionally from other Faculties than the Faculty of Architecture. I met the candidates beforehand, and they explained to me the content of their thesis. I chaired the promotion committees with professionals from all over the world, judging the defences of numerous candidates. I loved the ceremony, and the form of attack and defence as a critical academic debate. The person who defends or attacks is no longer

[a] Jong;Voordt(2002) *Ways to study urban, architectural and technical design (*Delft) DUP-Science http://team.bk.tudelft.nl/Publications/2002/Jong(2002)WaysToStudy(Delft).pdf

important, the subject matters as an object of scientific doubt. The research competence of the candidate is no longer the issue, but her or his ability to defend the work. Any thesis contains a table of propositions. Some of them represent the most risky part of the thesis, but others must represent subjects beyond the thesis. The propositions should be 'attackable'; Popper would say 'falsifiable'. The doubt always remains. It is the quality of the defence that counts. I enjoyed these sessions, and as a chairman, I could prepare the candidate to regard it as a game of defence and attack. "Humour is not forbidden, as long as it concerns the scientific subject. Any joke changes suppositions during the joke, and that is precisely the task of science." Instead of frightening the candidate, this appeared to relax her or his nervousness. I could then stimulate the committee to attack strongly and sharply, and not hesitate to say "Esteemed Promovendus, on page … you write … What a nonsense! …", which enabled the candidate to say "Highly esteemed opponent, you may be right in this respect, but …", and subsequently summarise where the opponent is definitely wrong. It was not difficult to change the religion-like style of the ceremony into an entertaining play, with impressive clothes and clauses. But, this transformation also resulted in the debate hitting the core of the scientific issue, and pushing the questions to their limits. A prescribed decorum helps to separate the issue from the person. Even a defeat is a victory for science. In 2011, I finished my membership with the Board for Doctorates, in order to be able to defend my own thesis, and to change my role in this beautiful academic ceremony, as it lives on in Delft.

The context of technology

From this experience, I learned the state of the art of technology in many of its branches. I was impressed by the thoroughness of the specialised theses, the prominence of mathematics, and of empirical research based on creative experiments. I enjoyed witnessing scholars force nature into exceptional states. This cannot be done in the humanities. I witnessed the emergence of bio-mimicry, which was focused on the increasing fascination of technicians on what is possible in biology. I asked the committee repeatedly "We still do not know much, do we?". They always agreed. Their modesty impressed me more than my own faculty's focus on fame. I developed some disdain about the products of architectural celebrities. Their experiments scored in cultural publicity, but not in amazing innovation. Winy Maas (MVRDV), however, appeared to be visionary with ideas such as the improbable Netherlands Pavilion at EXPO 2000, ten years before including nature in buildings became a serious object of research. Our department of Building Technology is inclined to creative experiments by Mick Eekhout, Karel Vollers and Kas Oosterhuis. In my department of Urbanism, however, history, and increasingly also management ('the process'), ruled the spirits. However, the results of the studios disappointed me. I suspected a lack of drawing capacity in the students *and* the teachers. Designers left the department in favour of text writers, who won the race into the accepted scientific journals. The only traffic engineer, Boudewyn Bach, retired. In practice, urban design lost ground to civil engineers, architects, landscape architects and real estate managers.

Education takes time

In 2000, the lack of urban technology was recognised in the department of Urbanism, and I started to prepare a course. After Ways to Study, my educational obligations were increased to 16 courses per year, but I managed to computerise them, thanks to my private secretary, Marlies Wenmeekers. She had some feeling for computer programming. Linda de Vos-van Keeken, the amazing head of the amazing secretariat of the department of Urbanism, supported me in obtaining the unique position of a professor with a private secretary. In ten years, approximately 4000 students made a website and published their take-home exams on the Internet. I judged them based on 5 to 25 criteria, and I published the specified marks on the web, in order to enable the students to recognise their strengths and weaknesses. Making a personal website appeared to be appealing for the students, because the first commission entailed the publication of earlier own design work. Having a personal website

with your own work is an advantage for applications and personal publicity. Other advantages of this system of examination, were the motivation to make projects clear for everybody to understand, and the fact that I became acquainted with the achievements in the studios, which were presented as earlier design work. The rest of the commissions could then contain questions about the methodological or technical characteristics of the designs, and their strengths and their weaknesses, from the perspective of what the students learned in the course. Plagiarism was excluded, because any website was focused on the individual's own design work. I will now go into some detail about the urban technology course, because it shows the requirement of time to make a proper design-related course.

Educating Urban Technology

Before I prepared the course on urban technology, I thoroughly studied the lecture papers of Boudewyn Bach. I transformed the calculations into interactive Excel sheets, and I made many new clarifying images. I supported Boudewyn Bach to preserve his heritage for education in a final publication, but this beautiful book was too expensive for the course.[a] I made my own cheaply downloadable lecture paper on urban technology. Every year I found new subjects missing in the course, and it was difficult to determine how to offer them in the right (conditional) sequence. In nearly ten years, the lecture paper expanded to 720 pages, with 1133 figures and 400 test questions, which frightened my colleagues and the students.[b] The student's reward decreased from 6 ECTS to 5, and from 5 to 4 ECTS, due to several U-turns with priority for management skills. But, it survived until my retirement. It finally included sun, energy, wind, noise, water, traffic, earth, land preparation, life, ecology, nature preservation, living, population density and legends for design with lectures, questions, downloadable powerpoints, videos and interactive computer programs for every chapter. Some computer programs had to be made as an executable file, but most of them could be offered as Excel files, enriched by Visual Basic routines and interactive sliders. They function at any computer. Every formula that was developed is shown and accessible for improvements. The students learned the ability of calculations to undermine popular beliefs. They also learned that technical calculations have their own dubious suppositions (parameters). You can doubt them and then ask the right questions. Particularly Asian students enjoyed the mathematical operations. Some of them even added valuable components. Making them was a great joy, but it took me approximately 2000 hours.

Breeding *awareness*

The educational goal of the course was primarily to make the students *aware* of the many technical problems they may meet in the urban design practice; it was not to make them specialists themselves. The main aim was to make them less vulnerable in the company of specialists, but there are many specialists in the field of urban design. How to cope with that multitude, and how to cope with a lecture paper that frightens students by its shear size? The primary requirement is to become able to find what you need. Google can help only if you know the right key words, and if you trust the diverse content of the Internet. The lecture paper should teach you the right key words, but this requires a systematic structure to find your way. The students had to learn how to navigate through the lecture paper. The navigation itself had to be exercised, in order to become familiar with the structure of the paper. A great means to exercise navigating through the extensive lecture paper was a multiple choice open book test of 20 questions that preceded every lecture, and concerned the subject of the chapter that would be explained *after* the test. The reward was a minor bonus in the final mark of the course (primarily based on the websites that were submitted at the end of the course) but the effect was remarkable. The students came in time and took their lecture papers with them. The lecture began with 20 minutes of silence, while students eagerly navigated through the extended lecture paper, forced by a new question that appeared on the screen every minute. The attention for the lecture increased, because it

[a] Bach(2008) *Stedenbouw en verkeer; Urban design and traffic* (Wageningen) CROW
[b] Jong(2009) *Sun wind water earth life living, legends for design* (Zoetermeer) lecture paper

provided the answers at unexpected moments. The students saw it as a sport to reach high scores, without having to be nervous about the effect in the final mark.

Back into ecology

The teacher, however, doubted the contents, particularly concerning ecology. For a short period, I was a member of the board of the Society for Landscape Ecology (WLO). This membership gave me the opportunity to become up to date with the state of the art in this branch of ecology. I edited a book with Jos Dekker, including contributions to 3 WLO-symposia with 32 authors divided in 3 sections: Nature, Town and Infrastructure.[a] I became acquainted with the culture of the ecology department of Wageningen University, and Jos bridged the difference between the ecology department in Wageningen and the Urbanism department in Delft. He became a true academic friend. In my lectures concerning ecology, I distinguished 5 types of ecology, which were related to different Universities in the Netherlands. The majority of the authors from the University of Wageningen (mainly filling the section 'Nature') were apparently related to one of them (but not as I expected according to my lectures), following the National policy of ecological networks that were funding them. The German peer judging the content, made the interesting remark that we overlooked the extended German literature on the subject. I began to read more German literature.

An ecology of scientific subcultures

The WLO culture, with its own Dutch journal, was very different from the culture of NECOV, the other ecological society that I knew, as a member. Their cheaper symposia were full of posters from PhD-candidates that were eager to explain their more diverse and more specialised biological research, and they were attended by a higher percentage of bearded biologists, who were apparently more fascinated by plants and animals than by humans and their artefacts. They reminded me of the members of the society for amateur biologists, KNNV, which had local departments in nearly every municipality in the Netherlands. Since 1992, I had edited the quarterly of the KNNV department Zoetermeer, with Johan Vos, the municipal ecologist of Zoetermeer. This club magazine is filled with enthusiastic reports that concerned the new plant species that were found every season in this new town. It has become a detailed and amazing natural history of a new town, covering 20 years, counting more species per km^2 than many Dutch natural reserves with the same content of rarity.[b] The section 'Town' of the WLO publication, which was published by the KNNV, contained the contributions of other municipal ecologists, and scholars from Delft, including myself. The section 'Infrastructure' mainly contained the contributions related to civil engineering. Thus, our book contained very different scientific subcultures. This, however, is not only the case in ecology. Meeting the professionals in the PhD-committees that I chaired gave me the impression of small global villages, specialised experts that knew each other in a very familiar way ("Nice to see you!"), united by their own language and specialised scientific journals.

Design combining specialisms

Much of the content of the book on landscape ecology could be used for my lecture paper on urban technology. It answers the question of why my chair was named 'Technical ecology'. For the students, however, this was only a minor part of a course, a train of wagons passing their rail-station as if it had no ending. They did not have enough time to realise that every wagon has different compartments as well. Therefore, the examination of the course had to start interrogating the students' own designs published on their personal website. There they answered the questions "What did you do with Sun, with Wind, with Water…?" and so on; "What *could* you have done, knowing what you know now?" and "What are you going to do with this knowledge in your *next designs*?". They *calculated* different

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[a] Jong;Dekker;Posthoorn(2007) *Landscape ecology in the Dutch context: nature, town and infrastructure* (Zeist) KNNV-uitgeverij

[b] See http://team.bk.tudelft.nl/Publications/KNNV.htm

aspects of their own designs, and I hope they became *aware* of the many ways their design can be judged by specialists in practice. I hope that they will not take these specialist's calculations and advice for granted. I hope they will be able to ask the right questions before they adapt their design into a traditional compromise. Though I was not involved in any studio in the last years of my teaching, the student's websites gave me a nice overview of their results.

Beijing

Some students requested me to become part of their graduation committee. They became true academic friends. Let me give one example. I cannot conclude much difference in the average quality of students from Europe and Asia, but there may be a difference in the extremes of disappointing or amazing students. According to the population, there are probably more exceptions escaping the statistic deviations in China than in the Netherlands. Xiaorong Zhang asked me to join her graduation committee for technical advice. She told me that Beijing suffers from heat in the summer, which causes many casualties. By replacing some neighbourhoods with parks, the government succeeded in reducing Beijing's urban heat island effect from +5 ◦C to +4 ◦C. Xiaorong wanted to make a design for urban renewal of an old authentic neighbourhood with narrow streets. What could be done that was better than relocating its inhabitants to the outskirts of the city, in favour of the wind? "I noticed that you have done wind tunnel experiments.", she said. "Yes, but that is a long time ago, and they are very expensive"."It does not matter, there are formulas now, in order to calculate the effects at a larger scale than buildings, and in order to compare different solutions." I was apparently not up-to date with my knowledge of wind modeling, and she sent me a French article with many formulas. The formulas and their complicated relationships requiried a lot of morphological data, which embarrassed me. I could not understand them without extensive study, but she mentioned them in her first graduation report, and had already drawn some preliminary conclusions. It impressed the other members of the committee, who did not have any understanding. They looked at me. I had to do something.

Fig. 252 The God of longevity

I mailed Xiaorong that she had to wait until I would have time to simulate the formulas in Excel during the Christmas Holidays. The first formula took me a day. Proudly, I mailed her the Excel file, and she answered the next morning: "Dear professor, you did an excellent job! What beautiful sliders and moving graphs you made! There is, however, something wrong in cell G30 and H5. I will look for a solution." I hastily restored my mistakes before she could send a solution. I mailed her the improved sheet and I started immediately to elaborate on the second formula, forgetting the time until Ellen, my wife, asked me for dinner. "It is our holiday!" … "Yes, yes." The story repeated 3 times, until I received a mail from Xiaorong with congratulations for the New Year: "Pff, that is complicated! I am in Rome now. As soon as I am back I will give you a reaction." I finally was on level with my student, and the results fit rather well with the experiments from 25 years earlier.

When she was back in Delft, she explained to me what I still had done wrong, by consulting 3 pages of written notes in Chinese characters. Some months later she graduated with a

nice design, and a train of extensive social and physical evaluations, of which my graphs were only one wagon. The committee could not understand all the details, and they asked her if she had not *forgotten* something. “No”. The committee could not find something missing either. After the graduation, I received a very nice mail full of gratitude, which contained the picture of *Fig. 252*.

Paramaribo and Gui Yang

I do not like travelling, but my true academic friend Peter Luscuere, professor in Building Physics from our department of Building Technology, invited me to join a delegation of the Dutch engineering bureau Haskoning into Guy Yang, and I did. The project is elaborated on page 181 of this thesis, but my impression of China was not very different from my experience in Surinam. The young man stayed in Surinam for one year in military service. He was increasingly impressed by the tolerance between so many cultures (16 languages) in such a small population (a third of a million at the time). He was particularly impressed by the very different, but always hospitable tribes surviving in the magnificent tropical rainforest for centuries. The young man was *trained* to survive there for a period of only one week. In the capital Paramaribo, the main Synagogue is located next to the main Mosque. People were joking about each other and about us, but they remained living in a model peace. A Christian girl wanting to lose weight, simply joined the Ramandan of her friends. It seemed as if they expected everybody to be different, joyfully celebrating the similarities of any encounter. In the Netherlands we are trained to expect equality, depressed by differences appearing in any meeting. Of course, the Netherlands and both other countries are different, but the increasing similarities worried me more: the same cars, hotels, airports, pollution and the same indifference in regards to nature. The difference between scientific disciplines is larger.

Adapazarı and Delft

In the same way, I was seduced several times to go to Turkey by my closest true academic friend Ali Guney, a member of my small Chair. He asked me for advice concerning Adapazarı, the place where he was born. The Lord Mayor of Adapazarı had visited his mother somewhere in the mountains, where he had learned that Ali stayed for holiday. This was very surprising, because Ali was a persona non grata in Turkey, due to his political past and his convinced atheism. The Lord Mayor, beloved by his citizens, and consequently being in office for an exceptionally long period, was an Islamite and the most moderate and tolerant person I have met, except perhaps Ali himself. Ali had been his link to Delft and he visited our University, with his wife assisting him with her advice in the meeting with our Rector Jacob Fokkema. He left a deep impression on me. He requested us for advice concerning his municipality, which was hit by a serious earthquake in 1999. The project is elaborated on page 247 of this thesis. In Turkey, I recognised the contrast of Atatürk´s revolution and the Islamic Ottoman remains everywhere. For me, the combination of history, religion and culture were more tangible in Turkey than in the other countries. It is the country where Thales gave birth to mathematics, and to the Greek and Western way of scientific thinking.

A Chair of true academic friends

Ecology is not a core business in a Faculty of Architecture, and I never had the ambition to extend the number of Chair members. This spared me the trouble in times of shrinkage and it would spare my successor to cope with co-operators (s)he did not choose. The physical geographer Riet Moens accompanied my first steps as a professor. She pitied the magic box of the young man she had already known as her student. For a short period her colleague Ina Klaasen (occupying the Chair Regional Design until Hubert de Boer came) joined my Chair … and Riet’s critical remarks. As a strong fighter for empirical research in design, she was my best opponent stirring up the Chair with weekly debates, sharpening its arguments. After her departure, these debates continued, often in the open air, at the covered balcony of my room with a broad view on the campus and the old town of Delft, where William of

Orange fought for tolerance and for our independence. Egbert Stolk, an excellent graduate, joined the Chair and the debates as a PhD candidate, convincing me to employ Ali Guney, a Socratic and a very literate teacher. Ali introduced precedent analysis as a necessary application of cognitive science in design education, inspired by Alexander Tzonis. The weekly debates descended into the most fundamental epistemological questions. Egbert, observing a repetition of arguments, preferred to organise international conferences with internationally famous participants on complexity, self organisation and cognitive science, to write books and articles, to obtain commissions and funds. He convinced the department of Urbanism to invite Yuval Portugali, the well-known geographer from Tel Aviv, as a guest professor on self organisation and cognitive science in the city[a]. He brought all kinds of celebrities of complexity theory into the Faculty. I attacked them at his conference, organised by Egbert. Batty was amused, Haken did not agree 'at all' and Salingaros threatened me beforehand not to attack him, but I did not receive any counter-argument from this society of believers. Yuval made many converts in the department of Urbanism, but he became one of my true academic friends. He was more than anyone else amused by, and interested in my objections. Concerned about the fading interest for design and possibility-search, I was happy that landscape architect Martin van den Toorn had joined the chair. He moderated the debate referring to many examples of large Dutch design projects changing the face of the country though design (without any self organisation or cognitive science), proving his impressive knowledge of literature. PhD-candidate Olgu Caliskan, an excellent graduate of METU Ankara, appeared to be an authority on urban morphology before his doctorate. He was *asked* by publishers instead of searching for them. He attended the debates with a distance of sound scientific doubt. With him, the variety of opponents seemed to be sufficient to exercise my loud objections against the returning hypes of thirty years ago, so irrelevant for design. The many international external academic guests attending our debate through the years, were frightened by our noisy debates in the beginning, but they gradually understood this kind of friendship. Academic guests add more than managers can imagine in publishing and putting local fashions into perspective.

Systems theory and cybernetics

After the debates regarding empirical science and design with Ina and Riet, issues of complexity, self organisation and cognitive science dominated the debates with Egbert and Ali. This reminded me of the arguments of young man against systems theory. Systems theory already attempted to cope with the 'complexity' of an observed diversity and dynamics that you cannot conceive. Systems theory assumes, that you do not have to understand the object and its internal process, if you study it as a 'black box' with an external input and an output. It may be sufficient to *construct* a process with similar inputs and outputs. This is useful if the input is properly defined, but in living systems you often overlook inputs. For example, birds are disturbed by your observation. Unconscious inputs in humans change their behaviour in the laboratory or if you ask them to fill in a questionnaire. Moreover, you cannot bring them in extreme and unnatural conditions by creative experiments as physicists, chemists and biologists can do. Psychologists, sociologists and economists are restricted to historical and anthropological data and to small deviations from normal conditions by experiments. The inputs of humans cannot be controlled, because they select them on their own initiative. Cybernetics adds to systems theory the influence of the output upon the input by feed-back. If the output does not agree with some standards, then the input is regulated by feed-back. Measuring the deviations of the impact of canon balls compared to their target deliver correction data to the canon for the next shot. The problem is, that these targets or *standards* may change *in* the black box if there are hidden inputs (for example in humans and in their societies). The amount and the diversity of co-efficient inputs of humans may be inconceivable.

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[a] Portugali(2008) Self Organization And The City. **IN** Meyers Encyclopedia of Complexity and Systems Science —Entry 759 Springer

Selection by the selected

Our imagination is limited. You may receive ample 100MB/s (10TB/day) from your senses. The physical access into consciousness is much slower. Less than a *millionth* part of these impressions can become 'conscious' and even less can be expressed in an understandable language.[a] The rest is unconsciously used for physical reflexes or immediately forgotten. Which selector selects the conscious part of these numerous impressions? Which selector subsequently decides which part will be expressed in some language or stored into our selective memory (1-10 TB)? Which selector, then, destroys the 'useless' memories in order to keep space for new ones?

What you remember are *similarities* that may be useful in the expected rest of your life. From these similarities you reconstruct an other reality called 'imagination'. This imagination is the basis of your expectations, desires and fantasies about *possible* and impossible objects. Repeated observations in similar conditions may produce *suppositions*, but the conditions are never the same. These *suppositions* may select the 10B/s from the 100 000 000B/s we observe in order to get through into your consciousness. These *suppositions* are the selectors of your consciousness, expressions and memory. They are, however, themselves the result of earlier selections. They are the result of a circular process of *selection by the selected*. The first supposition thus cannot be based on *similarity* if there are no earlier impressions to compare with. There must be a supposition prior to similarity. In this thesis I assume that it is *difference*. Similarity, then, is a special kind of difference, but it is still a difference. Everything differs. Any difference, however, is different from any other difference. If you cannot observe or imagine the difference, you *name* them 'similar', 'comparable' or even 'equal'. This 'equality', however is a supposition that cannot hold after any second observation, because this observation must be a different observation to be a second one. Even *counting* different objects assumes an equality between them that cannot hold if they are different. Difference is the language of the senses, similarity is the language of common sense. We call our set of suppositions 'knowledge' if it can be expressed in words, and if it is repeatedly tested by different persons as 'true' or 'probable'. In this thesis I have used the word 'knowledge' or 'cognition' with great reservations. Knowledge must always be questioned, and it may hamper the possibilities of diversity and of design.

Cognitive science

In a two-dimensional drawing, contradictions remain possible, as any designer knows. This designer's 'knowledge' cannot be ex*plain*ed in sentences or linear logic, but you can communicate it in drawings. If you accept proper drawings as scientific documents, it is no 'tacit knowledge'[b]. This 'knowledge' cannot be explained by analogies of computing machines. Why distinguishing the computer programming terms as 'declarative knowledge' for the variables, 'procedural knowledge' for the operations, and then add some 'tacit knowledge' as a kind of mystical human rest-category? Any 'knowledge' is a set of suppositions that direct and select your observations. These suppositions are called 'true' or 'probable' if they are tested, but you must stay questioning the suppositions of testing itself. The presupposed categories, variables and words of any test chain your imagination. Where are the modes of desirability and *possibility*? There are many more variables conditioning the input and the resulting output. There are many agents at another level of scale than what we observe as a unity, a system. But, that was already known and studied for decades in ecology. Most of its agents (species) are still undiscovered and their operation is still unknown. We still cannot cope with the irritating *diversity* of nature; that is the question. I cannot cope with it either, but I am at least aware of my limits. The level of scale is a crucial limit of observation and imagination. At every level of scale they are limited by two black boxes: one inside its grain of resolution and one outside its frame. This usage of the word 'frame' is substantially different from its usage in Cognitive science (activated suppositions).

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[a] Silbernagel;Depopoulos;Gay;Rothenburger(2001) *Atlas van de fysiologie* (Baarn) SESAM

[b] Polanyi(1966) *The tacit dimension* (New York) Doubleday

Complexity-theory and self-organisation

I do not require a concept of complexity to study different diversities at different levels of scale. Of course, Ashby[a] and Minsky[b] did a nice job, but every thirty years a similar 'new kind of science'[c], seems to result in a deterministic hype that limits the human power of imagination and design by the analogy of machines. I do not know much about Complexity theory, but I cannot escape the impression that it is a successor of systems theory with even less concern about the input. It, then, seems to be sufficient to construct a procedure with a limited set of inputs and operators in order to obtain outputs that seem 'similar' to what you observe. Complexity theory then can be named more appropriately as Simplicity theory. My moderate experience with computer programming taught me that many repeating feed-backs in a very simple program may result in a chaotic process and a sudden appearance of fascinating regularities in the output, but these regularities or *order* are not the same as *organisation*. The emergence of regular patterns in a random vector field appearing on computer screens is incomparable with an operational exchange between diversifying *organisms* selecting each other by ecological evolution, or with an *organisation* through differentiating cells and *organs* in an *organism*. The resulting *form* may be similar, but the scale-dependent structure and –operation are substantially different. You should make things as simple as possible, but not simpler.[d] The confusion of morphological *order* and chemical, biological and economic *organisation* reminded me of Ashby, McLoughlin[e], Odum[f], Prigogine[g], already written off by the young man as a religion of cheap mathematical analogies and generalisations. Smith's 'invisible hand' creates prosperity *and* disasters at different levels of scale. Chaos appears as order at another level of scale. If you are not aware of this scale paradox, scale falsification will disturb your senses, sense and sentences.

Dubious suppositions of classical empirical research

The debates regarding empirical science and design with Ina and Riet resulted in the publication with Theo of 'Ways to study and research urban, architectural and technical design'. This increased my appreciation of empirical research, but it did not solve the question already bothering the young man. Empirical research emphasises the input, but its attempt to *generalise* by *reduction* is a paradox I could not accept from a viewpoint of spatial design. Distinguishing a population for statistical analysis (a set) supposes already an equality beforehand of some 'properties' between its elements neglecting the differences. The term 'property' is problematic in the mode of possibility. The collection of data about a population defined by some properties (the input of the research) is the weakest point in statistical analysis, because any data set already assumes their comparability in one respect (the criterion of the set and its resulting variable). If the elements of the set are different in other respects, you will obtain a 'statistics on heterogeneous sets'. I cannot accept its results as completely reliable, because the conditions of the elements are not equal. A set of people (or any other species, any other ecological community) is heterogeneous by its still inconceavable biological diversity and so are their contexts. Statistical operations on a 'category' of people then cannot be valid by definition; their generalisation cannot be reliable in every context.

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[a] Ashby(1962) *Principles of the self-organizing system* **IN** Foerster, H.V.; G. W. Zopf, J. Principles of Self-Organization: Transactions of the University of Illinois Symposium (London) Pergamon Press p255-278
[b] Minsky(1985) *The Society of Mind* (New York, 1988) Simon & Schuster Paperbacks
[c] Wolfram(2002) *A new kind of science* (Champaign) Wolfram media
[d] Attributed to Einstein. See, however, http://quoteinvestigator.com/2011/05/13/einstein-simple/
[e] McLoughlin(1969) *Urban and regional planning. A Systems Approach* (Bristol) Western Printing Services Ltd.
[f] Odum(1971) *Fundamentals of ecology* (Philadelphia/London/Toronto) W.B. Saunders Co.
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Pragmatism in a limited context

However, generalisations may be *useful* in particular niches of application. They are particularly useful for marketing, because the average sells best. Statistical analysis interprets the deviations from a supposed average as different degrees of probability, but a heterogeneous set has no average. The consequence is, that the improbable exceptions are neglected. Exceptions are not important for marketing a product, but they are crucial in evolution and design and sometimes desastrous in statistical practice. For example, if you select a set of people with apparently equal diseases, and you give half of them a chemical substance and half of them a placebo, then you may conclude *on the average* a positive effect. The diverse and rare negative side effects, however, may be as different as the heterogeneous set you tested. If so, then each of these side effects is not significant enough to be mentioned in the leaflet, and they cannot be proven to be related to the medicine afterwards by statistical means. That is profitable, because then you can develop medicines for any of these rare side effects without blaming your previous medicine as being their cause. You create your clients. This is the way linear problem solving may cause more problems. Spatial design should solve problems with an awareness of the side effects. It is the power of drawing to show side effects perpendicular to any line of reasoning.

Generating instead of generalising diversity

Generalisation reduces diversity. Reducing diversity reduces possibilities and freedom of choice for future generations. Diversification *generates* possibilities, but how to create diversity? Creativity requires questioning common generalisations, suppositions. I do not pretend to be very creative, but I questioned some common suppositions (e.g. de concept of ‘equality’) in order to obtain more space for imagining possibilities. Questioning them, however, may threaten interest-based suppositions. I obeyed my parents, warning: “You should not generalise”. They payed, however, for the education teaching me the many ways to generalise called Science or Humanities. Doubting their generalisations is easier without a study dept to be paid by selling them. The message “You *cannot* generalise” is difficult to sell, and it undermines your living as a scholar. In the rare places, quietly separated from the dynamics of globalisation, rare plants may grow. My Chair survived in the shade of an international Faculty. It hided from the acoustic feed-back of fashion and fame. It was a place where doubt and debate florished in plain terms. The names I mentioned here, are not intended as the context of a personal biography. They are primarily intended to label the phases of a development clarifying the origins of this thesis. The persons behind them, however, were also true academic friends. I thank them for their objections, not for their approval. They changed and sharpened my arguments. I profited from their difference. We had not much more in common than loving doubt and debate. Some of them, however, did more to be grateful for. They sustained my efforts even if they disagreed, as a midwife does while it is not her child. My wife Ellen was the sacrificing midwife of this extramarital thesis. And my famous promotores Maurits and Dirk? Did they agree? I do not know, and I do not have to know. They took their precious time in order to read what I wrote. They judged my arguments, they skilfully advised to skip and to add. The least and most appropiate thing I can do in return is to publish my sincere gratitude in the end of this afterword.

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List of key words

See page 274 for the use of syntactic key words (with brackets).
Italics refers to pictures. **Fat** refers to authors.
Variables begin with a Capital.

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%floor space 132
%green area 170
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%humidity 178

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Propositions attached to

Jong, Taeke M. de(2012)Diversifying environments through design(Delft)TUD PhD thesis

In this thesis:

1. A linear language cannot cover space, its diversity or possibilities. (p281)
2. The meaning of words change per level of scale. (p283)
3. Educating design must start by drawing and modelling. (p287)
4. Difference is the language of the senses; similarity is the language of common sense.
5. Space enables the realisation of contradictions. (p287)
6. Mono-functional environments postpone the satisfaction. (p286)
7. Culture is a set of shared suppositions.
8. Creativity requires skipping at least one commonly shared supposition.
9. Images precede language. Language consists of routes in the image.
10. Separating functions saves time and cost space.
    Combining functions saves space and cost time.

Beyond this thesis:

11. Forms in-form; words re-mind.
12. Science is a design, not the other way around.
13. Geography and history limit imagination. The task of a designer it to make them.
14. If probability implies a causal sequence, then possibility implies a conditional sequence.
15. Arguments in science and the humanities score less than compliments.
16. Truth has no copyrights and lies should not be paid.
17. Commercial journals are the graveyard of science and the humanities.

These propositions are regarded as opposable and defendable, and have been approved as such by the supervisors Prof. Ir. C.M. De Hoog and Prof. Ir. D.F. Sijmons.

Stellingen bij

Jong, Taeke M. de(2012)Diversifying environments through design(Delft)TUD PhD thesis

In dit proefschrift:

1. Een lineaire taal kan de ruimte in zijn verscheidenheid en mogelijkheden niet dekken. (p281)
2. De betekenis van woorden verandert per schaalniveau. (p238)
3. Ontwerponderwijs moet beginnen met tekenen en modellen maken. (p287)
4. Verschil is de taal van de zintuigen; gelijkheid is de taal van het verstand.
5. Ruimte maakt de realisatie van tegenstrijdigheden mogelijk. (p287)
6. Mono-functionele omgevingen stellen de voldoening uit. (p286)
7. Cultuur is een verzameling gedeelde vooronderstellingen.
8. Creativiteit vergt het weglaten van tenminste één algemeen gedeelde vooronderstelling.
9. Beelden gaan vooraf aan taal. Taal bestaat uit routes in de voorstelling.
10. Functiescheiding spaart tijd en kost ruimte. Functiecombinatie spaart ruimte en kost tijd.

Buiten dit proefschrift:

11. Vormen in-formeren; woorden her-inneren.
12. Wetenschap is een ontwerp, niet andersom.
13. Aardrijkskunde en geschiedenis beperken het voorstellingsvermogen.
    De taak van een ontwerper is ze te maken.
14. Als waarschijnlijkheid een causale volgorde impliceert,
    dan impliceert mogelijkheid een voorwaardelijke volgorde.
15. Argumenten scoren in de wetenschap minder dan complimenten.
16. De waarheid heeft geen kopierechten en leugens verdienen ze niet.
17. Commerciële tijdschriften zijn de begraafplaats van wetenschap.

Deze stellingen worden opponeerbaar en verdedigbaar geacht en zijn als zodanig goedgekeurd door de promotoren Prof. Ir. C.M. De Hoog en Prof. Ir. D.F. Sijmons

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