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THINKING THROUGH DESIGNING

Design Theory 2017–2020

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Otto Paans studied horticulture and gardening in the Netherlands, followed by landscape architecture at the Erasmushogeschool Brussel (BE). Subsequently, he studied urban/public space design at the Utrecht School of the Arts and the Utrecht Graduate School for Visual Art and Design (NL) where he graduated *cum laude* in 2012. Furthermore, he studied philosophy at the Open University (UK), where he graduated with distinction in 2017. Upon completion of his urban design studies, he worked as a landscape designer.

He has collaborated in several European FP7 and H2020 projects in fields as diverse as urban design, circular building, renewable energy, resource recycling, medical science, material science, and product design as concept developer, visual designer and dissemination manager. In 2014 he published the monograph *Situational Urbanism* (Berlin: JOVIS Verlag, 2014) together with Prof. Ralf Pasel, followed by numerous articles on design theory and philosophy. In 2020, he received his PhD (titled *Creating Knowledge Through Architectural Design*) *summa cum laude* from the Technische Universität Berlin. This dissertation provides a comprehensive theoretical and practical body of work that explores the epistemic potentials of Research Through Design.

Currently, he works as concept developer/spatial strategist, visual designer and philosopher.

Ralf Pasel is professor for architecture at the Technische Universität Berlin and heading the Chair for Architectural Design and Construction Technologies since 2012. Previous he was following several international Guest Professor roles (amongst others) at the Universidad Catolica de Santiago de Chile and the Rotterdam Academy of Architecture and Urban Design in the Netherlands. In 2009 he was the curator of the 'Parallel Cases' exhibition at the 4th International Architecture Biennale in Rotterdam.

Ralf Pasel is the founding partner of pasel.künzel architects Rotterdam and of Pasel-K architects Berlin. Focusing on experimental housing typologies and construction in an international context, the office explores the intersection between research, academic education and architecture in practice. The practice has received numerous awards for innovative housing strategies, including the International Bauhaus Award for the transformation of slum housing in Chile as well as for new types of urban housing in Germany and the Netherlands.

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Introduction

Published materials are nowadays readily and everywhere available due to the ubiquitousness of the Internet and wide-spread open-access policies, which is a development in knowledge transfer that we unreservedly applaud. However, the Internet's sheer span and scope results simultaneously in the unfortunate fact that such materials are widely distributed, often half-hidden in previously published proceedings or uploaded on a variety of different websites. Therefore, while all materials are *in theory* digitally accessible, it is notoriously hard to get a hold of them *in practice.*

This is all the more unfortunate as the scattered availability may unintentionally convey the impression that the works of authors deal with widely varying topics that seemingly have little in common, while, if the materials were to be arranged side by side, a coherent theoretical scope or thematic orientation would naturally emerge. The fragmentation and distribution brought about by the Internet conveys the misleading impression that the thinking of the author(s) took place merely on occasion; solely for this or that conference; or otherwise haphazardly and rather arbitrarily.

This anthology of previously published materials attempts to remedy these two unfortunate circumstances. First, by collecting a selection of papers and worked-out ideas from the period 2017-2020 in one volume, these texts can be easily accessed. Second, by presenting them in a single continuous sequence, their overlaps, thematic convergences, common interest and shared methodology becomes easily discernible. Also, on this occasion, we would like to express our gratitude to all reviewers, editors and referees who provided us with valuable comments and insights, and who contributed – often anonymously – to the quality of these materials.

We as authors benefit from some reflective distance towards the contents of these publications. Their common themes stand out in sharper relief and we are more conscious of the places where our argumentation could be improved and/or extended. Some persistent shortcomings have come to our attention, as the overall line of thought to which these materials belong has further matured in the meantime.

Therefore, we revisited all the texts and improved and/or extended them where this seemed advisable. We always did so with two criteria in mind. First, to strengthen the links between the individual papers, so that their commonalities become more visible. Second, to improve the texts for better readability and argumentative clarity.

Taken together, these papers convey one important message that is reflected in the title of this anthology: namely, that *designing* is a scientifically valuable and genuine form of thinking that merits an autonomous status alongside other forms of thought. This statement might either come across as too radical or otherwise as belabouring an already accepted position. Neither is the case, however.

That designing is a manner in which research can be conducted is a widely accepted position. Granted, some of the definitions that are customarily deployed in the field of design research are admittedly "fuzzy around the edges". As such, there are many open questions still to be answered. However, the core thrust of this position remains undisputed, even if not all its details have crystallized into clear and distinct concepts that satisfy the – as of yet unfortunately definition-minded – academic mindset.

Often unique strategies and techniques enable designers to acquire insights otherwise beyond the reach of those disciplines that do not possess them. We should not shirk from defending this claim. It would be utterly strange if architectural design was presented as an effective way of conducting research, but that, when queried about what makes it actually so, it would provide no compelling answer.

When we maintain that designing is a form of thinking, we have mental and physical operations on three different forms in mind: (1) the commonly known forms of mental deliberation and rational decision-making, aided by concepts and conscious, reflexive feedback loops. We can think of this type of thinking as the operations that are customarily included in Kantian faculty of "understanding". (2) non-conceptual and pre-conceptual forms of mental processing, equally endowed with feedback loops and connected by reflexive relationships, but also closely linked to affective and emotive cognitive capacities, and as such closer to the Kantian faculty of "sensibility". (3) the application of (1) and (2) in what has been accurately called an "epistemological aesthetic". That is, the utilization of a variety of artistic media in an explorative process of a more-or-less purposive kind.[1] These three forms of thought are dynamically deployed in both artistic practice and design.

The epistemological aesthetic freely combines non-conceptual and conceptual contents, but it does so in ways that are often difficult to describe in precise, well-defined terms. At any rate, and at the most general level, we can describe thinking as a form of mental organization of materials, mediated through a plethora of physical, cultural and emotional means, some of which are closely related to our embodiment, while others are artificial or cultural.

The second (non-conceptual/pre-conceptual) and third (affective/emotive) forms of thinking are in certain scientific quarters often regarded with some suspicion. Because it is hard to describe in certain, well-defined terms what their role in the mental and expressive economy actually is, it is also difficult to describe in determinate terms how to value them. In this collection of essays, we attempt to overcome these expressive difficulties as best as we can by deploying language that carefully hovers between the evocative and the precise; the ruminative and the practical; the speculative and the descriptive.

The essays gathered in this volume deal with various aspects of thinking through designing. Each of the papers highlights one particular aspect of a larger, composite theoretical edifice that cannot (yet) be grasped in its totality, but the outlines of which become dimly visible. We have as it were, adopted a "design approach" to an academic question, by simply trying to unravel our questions by starting at one end, and just accepting that the road might lead to unexpected places.

Each essay deals with a specific topic related to our tripartite conception of thinking: the nature of architectural representation; the types of knowledge involved in such forms of representing; the role of drawing as a notational form of thinking; and the simulative attitude that underlies architectural representation and thought. Taken together, they illuminate the dim outlines of a steadily growing and multi-faceted understanding of designing minds and design processes.

The first essay, titled *Between Control and Reflection* was in its first version titled *Architectural Representation, the Controlled Future and Spatial Practice*. It was presented at the *Reflecting Histories and Directing Futures Conference* in Oslo, Norway in 2017.[2] The original version was presented by Boukje Ehlen, who significantly contributed to the original manuscript that was published in the conference proceedings. The new manuscript included here has been extended and edited throughout, in particular where it concerns the discussion of Kant's aesthetic judgement.

The core thought is that architectural representation has often been conceptualized as a form of control, or alternatively as a form of geometric description of an object that will at some point crystallize into something fully determined. This conception of architectural design reduces architectural representation to description – a position that does scant justice to its generative and aesthetic properties. This essay argues for a more nuanced approach to representation in architectural design, focusing less on control and more on reflection. In particular, the notion of Immanuel Kant's reflecting judgement, as worked out in the third *Critique*, inspired our discussion.

Early versions of the ideas contained in second essay, titled *The Liminal Dimension*, were presented at the *Design Principles and Practices Conference* in Barcelona, Spain in 2018. We titled that version *Describing Liminal Knowledge in Architectural Design: Knowing What we Do Without Knowing Everything*.[3] Subsequently, a separate article with the same title was published in the *International Journal of Design Education* in 2019. The essay included here is inspired on an early draft of that article, and the discussion on tacit knowledge has been significantly re-framed, restructured and extended, as has the section on the "liminal space" and its ramifications for spatial design. If anything, designing is an activity that actives multiple types and levels of knowledge. Facts or relations that one might be consciously ignorant of, may appear in drawings, ideas and artefacts. So, the designer does not know everything that would be relevant for fully developing his idea on the outset. One possible goal for design activity is to uncover and order these relevant aspects. This process takes pace in what is called a "liminal space" – the learning space where ideas are more deeply understood through representation, experimentation, probing and speculation. The core thrust of this essay is that the liminal space forms the operative backbone for architectural representation, and thus for its unique modes of thinking.

The third essay is *Drawing as Generative Notation in Architectural Thinking*, originally presented at the *DRS Conference* 2018 in Limerick, Ireland, under the title *Drawing as Notational Thinking in Architectural Design*.[4] This text has changed little, except from some changes that we thought would enhance its readability and a short excursus into the properly generative potential of drawing in architectural thought. Drawings – whether manual or digital – appear to us on screens or paper, mediated by our senses. As such, they are notations, although they differ radically from texts, who share the same notational format, but without the characteristics that make imagery unique. Our discussion here focuses on reworking and extending Nelson Goodman's needlessly restrictive concept of notationality, and delving into the rich, layered nature of drawing as enabler and *modus operandi* of architectural thinking.

The final essay, titled *The Simulative Stance: Architectural Design as Epistemic Enactment* was presented under the same title at the annual Conference of the Netzwerk Architekturwissenschaft at the Technische Universität Berlin in 2017. The essay appeared in the conference proceedings, titled *Artefakte des Entwerfens. Skizzieren, Zeichnen, Skripten, Modellieren* in 2020.[5] The version included here is slightly longer than the version included in the conference proceedings, as due to length restrictions, some discussion topics had to be omitted. Here we could re-introduce them. This essay extends the American philosopher Daniel Dennett's concept of the "design stance". This is the attitudinal disposition that causes human cognizers to regard objects in the world as designed or imbued with a functional purpose. The concept was introduced by Dennett in dealing with the topic of intentionality. However, we freely adapt this idea and argue that all forms of architectural design imply a "simulative stance", that is, an enactive attitude that actively simulates and works out real-life possibilities for change through design.

Lastly, these essays were written during the completion of the PhD research *Creating Knowledge Through Architectural Design* by Otto Paans. As such, they are grouped around a group of sources and authors that were important influences on the direction and scope of that particular research project. The essays bring these sources and authors together in varying constellations, often using singular insights to illuminate concepts from two or three different angles.

Taken together, these essays highlight various aspects of architectural design as a genuine form of thinking. In discussing selected key aspects of the design process (creative exploration, control, learning, notating and simulating), we highlight how this claim unfolds in practice. As such, we have attempted to explore the threshold that – once crossed – may grant access into a new evolutionary stage of the design disciplines.

Between Control and Reflection

The Controlled Future in Architectural Design

1) Introduction

The precision of digital drawing techniques is breath-taking and seems omnipresent. No matter how closely one zooms in on a drawing, its lines remain thin and sharp, the corners well-defined. In turn, calculations afforded by building information modelling (BIM) or similar programs support the perception that all aspects of a building can be modelled, their properties viewed and juxtaposed at any moment. This sense of control and precision extends throughout the digital workspace enabled by computers.

This feature makes control the great equalizer throughout the design process: in all stages, maximum precision is possible. This extends well beyond the design process proper. It directly feeds into the construction process, as digital drawings can be used to manufacture prefab parts, extending numerical precision into the physical world.

But we are certainly justified in asking how this seemingly omnipresent precisions relates to the research aspects of architectural design. After all, the entire idea of research is predicated on the idea that something is to be discovered. And all-out precision seems to contradict that very fact, removing the openness and sense of possibility that all research implies.

Therefore, we first examine two deep-rooted assumptions about architectural practice and explain how these assumptions still structure thinking about the architectural design process (section 2). Then, we present a short theoretical excursus explaining how these assumptions shape our thoughts about achieving urban sustainability (section 3). Subsequently, we explain how these assumptions can be bypassed, providing explicit reference to the notion of drawing as tangible speculation and to Immanuel Kant's doctrine of reflecting judgement (section 4). Furthermore, we demonstrate with examples from our own research how this theory can be put into practice (section 5). In the conclusion (section 6), we reflect on some of the consequences of our methodology for architectural practice and the role of future-making.

2) Two Assumptions about Architectural Practice

The emphasis on numerical precision in architectural design has existed at least from the Renaissance onwards, notably when Leon Battista Alberti (1404–1472) introduced metric scale units in architectural drawing. Scale drawing linked architectural design to metric accuracy, allowing architects to externalize their thoughts into representations with a degree of precision that allowed for questioning and probing their ideas based on dimensions and precise insight in proportional relationships. With the introduction of the scale drawing, the architectural representation increasingly became the site for experimentation and criticism.[6] Alberti himself lamented that the building details which looked good in the imagination fell short of his expectations once drawn on scale and fell short again once built in a model.[7] Clearly, each form of representation, whether mental, on paper, or in a model, provided information on some properties that were not visible or deemed irrelevant in a previous step.

Where architectural drawing historically represented an order of inference that ran from mental representation to externalized drawing or model and back (fig. 1, above), this loop has currently changed shape. While drawing inferences from artefacts was mainly based on spatial and constructive properties, the numerical character of digital modelling tools has shifted the focus towards optimization and the structuring of spaces through digital simulation in a virtual space of total control (fig. 1, below).

Numerical precision serves as a device for intellectually grasping spatial characteristics. In turn, this approach serves as a device for control and forms of understanding that are focused on conceptual contents. The early modern tradition of science, resting on the Enlightenment idea of an external world that could be dominated and controlled by means of technology, finds its core premises affirmed by the numerical precision enabled by digital technology. Comprehending the design process is almost completely synonymous with full control over the design process and the properties of the object-under-consideration.

If control is the prime objective of architectural representation, then achieving exactitude naturally becomes the most important strategy in doing so. The focus on precision, control, and exactitude became a dominant theme in the development of functionalism in modernist architectural design at the beginning of the twentieth century. As Matthew Nowicki once argued, the term "functionalism" itself underwent significant change in the period from 1920 to 1950. During the 1920s, when architects spoke of function, they meant exactitude: an organizational and spatial definition that could be precisely determined before realization started.[8]

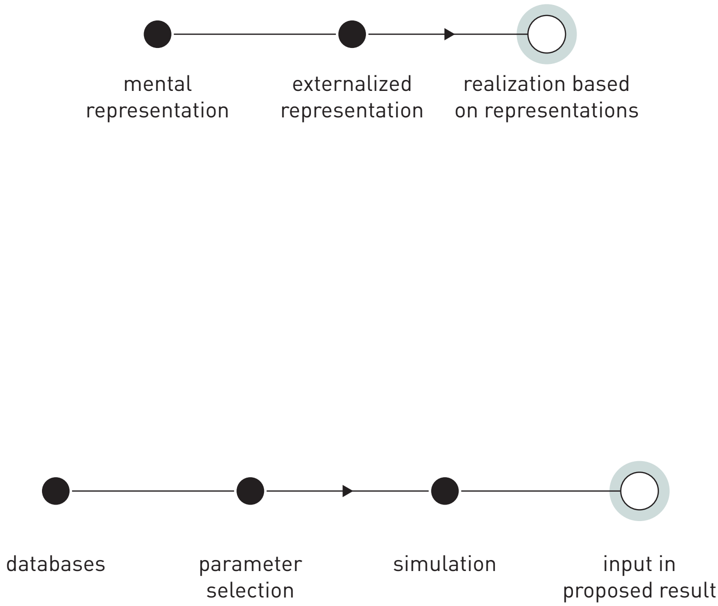


FIGURE 1:

TRADITIONAL ORDER OF INFERENCE IN ARCHITECTURAL DESIGN (ABOVE) AND A NEW ORDER OF INFERENCE THAT HAS DEVELOPED DUE TO THE INFLUENCE OF DIGITALIZATION AND THE USE OF LARGE BODIES OF DATA (BELOW). IN THE CASE OF THE NEW ORDER OF INFERENCE, SIMULATION OF SELECTED PARAMETERS REPLACES EXTERNALIZED REPRESENTATION.

This necessitated in turn a precise functional description of the object-to-come, a descriptive geometry, the justification of which was sought in the quantitative methods deployed in the natural and engineering sciences.9 Well into the 1960s, the tendency to think of problems as entities that should be completely understood before any solving (or designing) started can be found in its paradigmatic formulation in the *Introduction to Design* (1962) by Morris Asimow:

> *Synthesis refers to the fitting together of parts or separate concepts to produce an integrated whole. The synthesis step begins formally after the design problem is well understood, although some notion about possible solutions may have already been suggested during the prior steps. The point to be emphasized is deceptively obvious; concentration on possible solutions should not begin until the design-problem has been studied and identified, and a reasonably good working formulation of the problem set down.10*

Asimow contributed to the development of a decision-theoretic, mechanistic view of design processes: all attempts at synthesis had to be preceded by analysis, giving rise to an impressive range of design models by theorists throughout the 1960s and 1970s.

This type of procedure is in general undoubtedly useful for architectural practice. However, the real issue is that architects means something quite different than engineers when they speak about synthesis. However, the decision-theoretic model of design won out, and further ingrained two deep-seated assumptions about architectural design:

1) That architectural representations accurately and exhaustively represent the object-to-come.[11] At first sight, this thought seems completely plausible, and it seems to support the current architectural practice: How can a building or city be built if it has not been designed and represented first? However, as Alberto Pérez-Gómez notes, what makes architecture unique as a discipline is that it creates the artefacts and representations that make good buildings (and cities) possible in the first place.[12] The practice of architecture as a process of conception is a necessary condition for conceiving good buildings (in the triple Vitruvian sense of *venustas*, *firmitas*, and *utilitas*) in the first place. But, despite Pérez-Gómez's attempt to argue otherwise, this assumption lends credit to the idea that the abstract reality of representations is fully synonymous with the unmediated reality on which they are projected.[13] On this view, artefacts like sketches or models embody attempts to predict the properties of the object completely in advance. However, extrapolating from Alberti's case, this assumption is not as obvious as it seems. The idea of drawing as a descriptive (and predictive) geometry turns out to be utterly questionable, as despite its descriptive properties, drawing and sketching fulfil explorative

and speculative roles. If the designer knew exactly what to make in advance, then preliminary sketches would not be necessary at all.

2) That design problems can be exhaustively represented and controlled in the process of solving them. Notwithstanding the refutation of highly formalized process models of the first generation of design thinkers, and the contemporary focus on reflexivity in design, digitally affordable precision throughout the design process has again introduced the idea that understanding a problem is synonymous with solving it, or is at least a critical precondition for starting to solve it.[14] This idea is at least traceable to the seminal paper on wicked problems by Horst and Rittel, as they introduced the core idea that describing a problem structure is synonymous with solving the problem.[15] If one accepts assumption (1), then this thesis is correct, as the descriptive geometry represents a full understanding of the problem. If one does not accept the first assumption, then the notion of full control during problem-solving topples as well. The focus on exactitude engenders a further consequence: it merges the roles of architect and building engineer. Asimow was an engineer but thinking in Analysis-Synthesis models has proven remarkably persistent in theorizing about architectural design. But as already remarked, designers and engineers might use similar terms, while meaning something quite different.

So, the influence of the first generation of design theorists continues, although in a form they probably did not foresee.[16] Nevertheless, their view on design gave pride of place to defining functions – a theme that is still prevalent today, and that is often called building or urban programme. Such functional programmes are devices for control and predictability, leading to rough-and-ready guidelines and requirements for making design decisions. This thoroughly modern approach to design is still with us today, seemingly providing control over problems of an ever-increasing complexity.

3) Architectural Practice and Urban Sustainability

A contemporary version of the "exactitude-oriented" way of approaching architectural design can be discerned in the way the problem of achieving urban sustainability is defined and approached. Given its complexity, the prevailing trend is to resort to technological means to bring the problem scope under control. Data management has become a mainstream strategy for dealing with sustainability problems, largely marginalizing spatial practices, and redefining sustainability problems as sets of interconnected quantitative parameters, thereby forcibly positioning digital simulation and analysis at the centre stage of architectural practice.

The degree to which performance has altered the perception of what architectural practice is can be perfectly (albeit anecdotally) illustrated by reviewing two recommendations by the *2013 IEA Technology Roadmap Energy Efficient Buildings:* the first stressed that architects should "stay current with the latest building science advances, obtain sustainable design credentials and assist in educating other building practitioners".[17] The second recommendation stated that architects should "help present a business case for going beyond traditional efficiency measures, through experience gained on value-added projects."[18]

In both recommendations, the idea of architecture as a form of designing that extends beyond mere technical problem-solving, assignment of functions, or a process that is necessary to produce qualitative living environments is curiously absent. Instead, architecture is presented as operating under the wing of building technology, obtaining its operational norms and values from sustainable design credentials, and is recommended as a tool to be used for showcasing what is possible with building technology.

A second case that demonstrates the importance of quantitative data in dealing with urban sustainability problems is the usage of the term "urban metabolism". The idea is that cities function roughly analogous to organisms, exchanging goods, resources, and information in a complex of processes and transactions that are isomorphic to metabolic processes found in nature. This concept appears useful, as it draws attention to resources used in realizing and sustaining an urbanizing world, as well as the logistic complexity of flows and streams. As a tool for designing, however, we critically question its value. Foremost, because the notion of an interconnected web of resources almost demands that every conceivable consequence of realizing or proposing a new spatial design is reviewed in detail.

Two influential publications on urban metabolism stress the quantitative ramifications of the functioning of urban areas and make the problem of the chain of consequences perfectly visible.[19] In both cases, multiple resource flows to achieve urban sustainability were introduced as the building blocks of an urban metabolism. Resources such as sand and clay, energy, food, waste, building materials, and water were presented as vital components of a complex network that had to be quantified to design responsibly.

This approach changes the order of inference in architectural design fundamentally. Every design decision is conceived as something that must justify its existence by supporting the decision with data. This procedure reminds one of Nowicki's timely observation: not functionality as such, but a search for continuous exactitude guides contemporary architectural design processes. Every inference drawn from architectural representations is viewed with the tacit demand for exactitude and justification in mind.

Obviously, justification is an integral part of an architectural design process. However, the questions immediately arise as to why the justificatory reasons being supplied are largely quantitative, or whether the architectural design process and its argumentative support can be reduced to the domain of numbers. The pressing concerns and complexity of achieving urban sustainability, combined with the seemingly flawless precision and control of digital simulation, regrettably push architecture and urbanism into a direction that is unfortunately narrowly quantity-oriented.

Without denying the usefulness of quantification, or suggesting that simulations should be ignored altogether, we would like to raise the suggestion that architectural design practice cannot and should not be reduced to an all-too-exclusive focus on numbers or simulation outcomes. Nor is the assumption warranted that descriptive geometry accurately or fully describes the object-to-come. Architectural practice attempts to catch more than just numerical performance indicators or descriptive properties. It does not concern itself just with describing objects-to-come. Instead, it is a practice that entails all this, but goes significantly beyond it.

4) Architectural Designing as a Chain of Modelling Spaces

Architectural representation relies on different modelling spaces of its objects, starting from spatiality and architectural qualities that critically engage with modelling tools for quantitative evaluation. Each modelling space brings out different aspects of the architectural object-to-come.[20] A charcoal sketch of an urban plan catches, in broad strokes, its compositional essence or its most basic elements. However, a drawing made with a fine ink pen affords a very different sense of precision, as does the use of a physical cardboard model. In turn, digital tools allow for still further precision, arrived at through numerical and simulative precision. The range of artefacts resulting from this chain of modelling spaces is a so-called "interpreted world" in a dual sense: (I) it is an architectural microcosm made up of many, often overlapping ideas and (II) simultaneously it is an interpretation of how the physical world ought to look.[21]

Michael Graves proposed a three-category model for this chain of modelling spaces: the referential sketch, which associatively unites ideas, fragments, and forms of spatial organization; the preparatory study, in which options are generated, refined, and compared; and the definitive drawings that catch as much of the object as possible.[22]

On Graves's classification, architectural drawing is an image of something that is essentially and irredeemably incomplete. For a drawing (or, more generally, representation) to function as an interrogative or explorative device for an idea, it needs to be incomplete, while visual representation is applied as a tool of exploration and explication. Various forms of visual and spatial representation are used in parallel to explore and shape an object whose outlines and contents are just dimly known, although its ultimate form remains in a realm beyond the reach of cognitive access. Repeated representative efforts explore the properties of such ideas, mediated via various types of modelling. The modelling spaces implicated in this explorative process are not only numerical—they are constituted by different ways of working such as sketching, painting, and building. Moreover, they are focused on different themes, such as materiality, tectonics, contours, organization, or haptic qualities.

The realization of a building or urban plan is the culmination of insistent and directed questioning and the development of compositional variation by means of an interrogative, architectural practice centred around artefacts like drawings, sketches, paintings, referential scribbles, diagrams, and models. Graves echoes the insight of Pérez-Gómez when he states that even the final drawings of a building leave things open and unsaid about its ultimate intentions and properties.[23]

To rely on representation is to rely on a medium that depicts and leaves out properties at the same time.[24] The power of effective representation is to leave out just enough to allow for depicted content to generate new knowledge. From this viewpoint, one could conclude that the chain of modelling spaces jointly succeeds in capturing something that numerical simulation and digital exactitude cannot provide but can only support. De Bruyn and Reuter put this point very accurately:

> *The whole is always more and something different than the sum of its parts. For the process of architectural production, it follows that it is not allowed to arrive from the characteristics of individual parts or their law-like interactions at a description of the whole. The relations and connections between parts are of differentiated strength and possibly unstable. Partial systems serve divergent goals like ecological efficiency, aesthetic concept, social acceptance etc. Their harmonisation follows no verifiable function.*[25]

The plurality of goals served by spatial designs like buildings, public spaces, neighbourhoods, and cities cannot be subsumed under one verifiable or quantifiable function: they are simply too divergent and may at best be balanced relative to one another. The chain of modelling spaces allows for this act of balancing goals and functions, as each tool allows for addressing the problem with a different degree of precision or thematic focus. The chain of modelling spaces captures different qualities of the object-under-consideration. In this chain, digital drawing, simulation, and quantification have their rightful place, but they are not the only players on the field. Modelling spaces that deal explicitly with quality should be an integral part of architectural design practice.

The reason for this is that digital modelling space excludes as much in terms of qualities as it adds in terms of control.[26] The digital space is a

Various forms of visual and spatial representation are used in parallel to explore and shape an object whose outlines and contents are just dimly known, although its ultimate form remains in a realm beyond the reach of immediate cognitive access.

The power of effective representation consists in leaving out just enough to allow for depicted content to generate new knowledge. The chain of modelling spaces jointly succeeds in capturing something that digital simulation and exactitude cannot provide but can only support.

tool that cannot depict the "invisible" or the "unsaid"—precisely those ephemeral, phenomenal and poetic qualities that architects presumably would be interested in, and that can be addressed by linking modelling spaces focused on different themes. One might think of the play of light and shadow on different surfaces here, the haptic, tactile qualities of materials, the atmospheric qualities of a composition—or, as Graves indicates, not so much the exact description of the object-to-come, but the dynamic tension between its elements.[27]

It may be objected that these factors are perfectly predictable. The availability of lights and cameras, the existence of rendering programs, the myriad of programs to predict specific performance parameters all signify an expansion of the intelligible (real) space on the transcendental space of architecture.

This objection draws attention to assumption (1) introduced earlier: this type of representation rests on certain assumptions, most notably on the idea that the architectural representation is an accurate, exhaustively descriptive depiction of the object itself. Furthermore, it rests on the assumption that numerical representation sets the most accurate agenda for drawing inferences from an architectural artefact. The notions of control and predictability are ingrained in the modes of representation, reducing an architectural idea to its technical, controllable factors, with the numerical expression as an operative device.[28]

To revive the idea of an explorative architectural practice focused on spatiality and representation without being revisionist, we must give up on the idea of architecture as an accurate, descriptive geometry and the associated idea of total control and predictability. This also implies that we must give up on the notion of the designer as a merely technological subject.

This move undermines both assumptions introduced earlier and departs from spatial practice and architectural representation as core methods for projective reasoning. To give up the notion of full control, two preconditions must be fulfilled.

The first precondition is to reconsider the nature of architectural representations that are generated in the chain of modelling spaces: they may be best understood as a hybrid of narratives, materials, and guided perception, expressed in an array of visual tools.[29] Architectural works are therefore best understood as "image-space-text"—a rich, semantically saturated texture woven of the representations of spaces, images, and texts that is not reducible to either one of them.[30] When applied to the problem of urban sustainability, this observation yields the outcome that the focus on efficiency and quantification misses an important point: the architectural side of the problem is under-represented and has been only sparingly investigated yet. The incompleteness or tentativeness of architectural representation provides (non)conceptual angles from which to question, refine, and shape an architectural idea that exists as an object that is not-yet-present. Attempts to represent an object cannot be exhaustively descriptive: the object itself comes only into existence through attempts at describing, delineating, or representing it. Multiple acts of drawing, sketching, rethinking, modelling, adding, subtracting, and modifying are necessary steps in a chain of reasoning without which the object cannot exist:

> *The object does not await in limbo the order that will free it and enable it to become embodied in a visible and prolix objectivity; it does not pre-exist itself, held back by some obstacle at the first edges of light. It exists under the positive conditions of a complex group of relations.*[31]

The idea that objects pre-exist in ready-made form and can be hauled into existence by accurate description is a myth, a fantasy that posits objects that require a genius to haul them into reality. The object does not come into existence through exhaustive description, but efforts of describing and depicting the object are necessary steps to investigate the conditions under which a given object can possibly exist. Foucault draws attention to the fact that objects are fully embedded in the world—and this insight applies especially for architectural objects that are intimately linked to contexts and sites.[32] This embedding does not happen without prior thought: the architect has to think of ways to establish a natural continuity or entanglement between object and context, a task that is made all the more daunting because the object being designed does not exist yet.

Individual representations only contain selected features, necessitating the chain of multiple modelling spaces. By overlapping all of these incomplete representations, the architectural idea can be questioned, probed, and explored from different perspectives, with different tools, material applications, and with varying degrees of precision. The overlapping chain of modelling spaces creates a kaleidoscopic, yet accurate model of the architectural idea, even if it is not descriptively and geometrically complete. The act of representing allows for drawing inferences, based on the assumption that the artefacts are somehow isomorphic with a wide array of phenomenal qualities of the object.

The second precondition is to rethink the designer himself: instead of assuming the role of a controlling, technological subject, we may reconstitute the designer as a reflective subject. We can already find such an account in the last *Critique* of Immanuel Kant.[33] Kant explicitly placed the imagination at the centre stage of creation.[34] Imagination cooperates with and enables reflective thinking: conceptualizing what one sees by reasoning from one's subjective point of view.[35] In turn, this skill allows one to make so-called reflective judgements—namely assertions about the composition of objects, their aesthetic value, the emotions they evoke, what they seem to leave unsaid, et cetera. In short, this capacity allows one to address precisely that phenomenal register which is largely excluded by reductive modelling space of the digital realm.

Kant viewed reflecting judgements as acts of aesthetic acumen. The idea that a split between the aesthetics of an idea and its technological implications exists is non-existent in Kant's philosophy.[36] Instead, it is the formalizing science of geometry – when combined with the aesthetic sensibility of the reflecting judgement – that enables the "aesthetic of feeling", expressed in geometric forms, but by no means reducible to them. For Kant, the artistic or architectural representation cannot be just a descriptive geometry. If anything, it is an aesthetic mark in the manifestly real world. The effects of these marks can be scrutinized as products that are not just descriptions, but that are present as objects saturated with a tangible meaning that surpasses pure functionality.[37] We may use Kant's term "purposiveness" for this rich and fertile quality that forms the substrate for the imagination. The aesthetic marks open onto a new domain, the outlines of which can be apprehended, but not controlled. Therefore, if we view the design process from Kant's perspective, the designer is not a technological subject; his grasp of geometry is just one side of the coin and is meaningless without the emotive, aesthetic and affective contributions of the reflective judgement, its integrative counterpart. The designer is a reflective subject, making aesthetic judgements throughout the design process, and using geometrical determination and formalization as one instrument alongside imagination, instead of utilizing it as the main method of modelling.

Purposiveness—and with this, exactitude—is an important component of geometric description. It is "often admired", but not "merely subjective and aesthetic".[38] In purpose, the beauty of geometry and aesthetics come together. Kant holds that our reason for the admiration of geometric representations is an interplay between the imagination and concepts.[39] The understanding of rules, axioms, and guidelines must work in conjunction with the creative, generative imagination to create judgements that can lay claim to discursive intelligibility and assent to universality.[40]

As discussed, objects do not wait ready-made, as even the concepts or ideas on which they are based must be gradually developed.[41] Kant provides a formal model for their conception here. The imagination supports and develops judgements that are in the interplay of non-conceptual and conceptual content. Imagining is, on Kant's account, not a kind of fantasy or idle conjecture.[42] It is a synthetic, integrative capacity that fuses sensibility and creative thought into conceptual thinking, ultimately expressed in geometry.

Krippendorff provides a different conceptual angle to support this thought. His idea of the "ontogenesis" entails that designers work on artefacts that have no clear beginning or end.[43] Each artefact includes some presuppositions of its predecessors, and its status is not even fixed at the end of a design project. It is as if it were genetically related to its predecessors and to the world at large. Moreover, the products of architectural design processes are not permanent. They are transitory products that must nevertheless be described and defined. The creative thought embodied in each artefact is as if it were readable in its form, its presuppositions and shortcomings. Conversely, in order to be able to read artefacts as such repositories of knowledge (and failures), a kind of formal representation is necessary. To judge merits and limits, Krippendorff suggests, architectural representations must be seen as transitory stages in a continuous chain of ideas extending into the past and the future. How this works in research practice will be discussed in the next section.

5) Examples of Designing as Research Practice

By (I) positing the designer as a reflecting subject and (II) rethinking the idea of full control over design problems we can rethink architectural design processes and future-making by starting from spatial representation. In several research projects, we developed a design approach that changed the order of inference—not in the direction of quantification, but in the direction of architectural representation. The underlying idea was to remain true to the core competence of designers: to think in spatial arrangements on the one hand, and to think in terms of different disciplines (design, construction, material, ecology, sustainability) on the other.

Our approach starts with elaborate analyses of the area that requires redesign. It combines different types of scale drawings: classical maps, diagrams, and a sampling of data deemed relevant at that point in the investigation. In keeping with Krippendorff's idea of ontogenesis, analysis is not just geared to mapping properties, but also to understanding the wider context for the intervention. Instead of focusing on single, well-defined problems, the idea is to see why the architectural context gave rise to the problems in the first place. During this analysis, any architectural ideas that come up—even if they are preliminary and conceptual or downright utopian—are documented.

No matter how narrow the focus of an idea is, or how unlikely it is to be realized, the option is documented and kept in mind. This collection of data, maps, diagrams, sketches, and representations is subsequently mined for inferences: the output is treated as a body of information from which patterns emerge, or in which certain solutions can be found that may be used as inspiration or "primary generators" for new and more refined representations.[44] This process is iterative, becoming more focused with each cycle. During later iterations, digital simulation can be applied to each of the proposals. In the first instance, the idea is to be generative instead of precise; projective rather than confirmatory; explorative rather than decisive. In short, this approach starts with a general modelling space that is oriented not towards exactitude, but towards generation and variation.[45]

The advantage of this procedure is that it advances by creating architectural representations primarily concerned with space, spatial qualities, and an integrative vision of the output. Instead of abstracting individual features of the project area, as one would do in a digital simulation, each representation aims at bringing different architectural aspects (like construction, program, ecology, materials) together in a series of deliberately open-ended design ideas. The act of designing is used in an exploring manner. It supports the observation by De Bruyn and Reuter: multiple goals and functions of an architectural design proposal must be balanced through proposals in which functions are made specific in relation to each other.

Representations make the struggle between multiple aspects visible and tangible. Each representation clarifies the abstract complexity of design problems by focusing on real objects with intelligible, spatial properties. Representing makes important factors for addressing design problems visible. In turn, each architectural representation becomes an object of inquiry and collective scrutiny: its contents can be discussed, criticized, and compared.

This body of output can be used to form integrative future visions. Especially in urban projects, this feature has proven to be extremely useful, as urbanism deals with multiple subject areas at once. In many cases, optimizing one factor over others would lead to plans and proposals that are suboptimal. This type of working allows fully for what Bryan Lawson once called "working in different mental modalities", but also working with different themes and balancing their interests relative to one another.[46]

In the research project *City and Wind: Climate as an Architectural Instrument*, multiple connections between urban climate and the layout of the built environment were investigated with the goal of deriving design tools from them.[47] By studying the behaviour of wind in different architectural settings, ranging from vernacular designs to complete urban areas, the fundamental mechanisms underlying the behaviour of wind were mapped and these insights were applied in a range of study projects.

For instance, the study project *Windscape City* (fig. 2) proposed a new design scenario for the Maashaven area in Rotterdam (NL). This city area is characterized by a homogeneous urban fabric that directs the wind stream in a haphazard way around and through the site, leading to unpredictable effects like falling winds and sudden changes in wind speed. By adjusting the degree of porosity in the urban fabric, letting wind in at some places

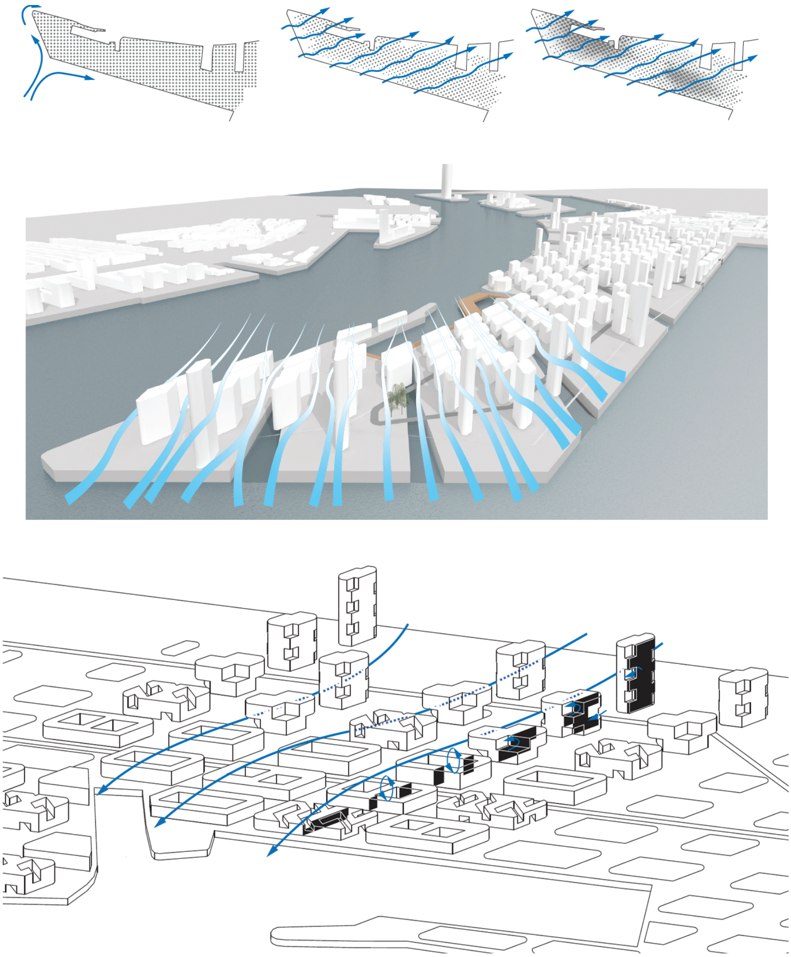


FIGURE 2:

WINDSCAPE CITY, WITH THE DESIGN PRINCIPLES (ABOVE) THE WIND CORRIDORS THROUGH THE SITE (MIDDLE) AND THE BUILDING POROSITY AND ITS REGULATIVE EFFECTS (BELOW).

and redirecting it at others, the climatic influence is regulated. This leads to a more predictable and friendlier climatic experience in everyday use. The parameters for building porosity had been defined earlier in a wind tunnel, translating the behaviour of wind into spatial arrangements and design principles. (fig. 3)

The advantage of translating measured wind behaviour into spatial arrangements, such as carefully sculpted buildings, is that the output of the research is spatial instead of numerical, and therefore readily applicable in design processes. Wind tunnel tests produced not only a quantitative database, but a spatial database, the features of which are intelligible to designers. This type of research familiarizes designers with the links between measured data and its spatial implications, leading to an understanding that is immediately applied. It translates quantitative data into architectural objects, closing the gap between numerical exactitude and architectural idea by fusing the former into the latter. Admittedly, there is an act of translation (or interpretation) between the measurements and the design of building shapes or the formulation of architectural strategies. However, this act of translation is an act of designing (or, following Kant, a properly reflecting, integrative act) leading to architectural outputs. One could imagine a new, invigorated role for architectural research and the formation of urban visions here, especially in the context of achieving urban sustainability.

Approaches like these enable problems related to urban sustainability to be defined as architectural problems—actual issues that can be addressed from within the designing disciplines, utilizing the expertise of designers: the conception of spatial arrangements.

In a different urban research project titled *Situational Urbanism*, we approached the translations from observations and quantitative data in a different manner.[48] The target area for this research project was the impoverished post-war urban district of Overvecht in Utrecht (NL). Like numerous other urban expansions from the post-war period, this area had been designed according to strictly functionalist, modernist methods. To address the housing shortage in the decades following the Second World War, the plan was conceived in a very short time during the early 1960s and was realized almost directly afterward. Together with the influx of immigrant communities throughout the 1970s, the neighbourhood started to deteriorate due to a plethora of societal developments, and the public perception of the neighbourhood was that of a typical failure of post-war architecture.

To map the chances and potentials of this neighbourhood, we developed a so-called situational analysis (fig. 3). Instead of just studying sociological and demographic data and urban plans, we identified potentially problematic situations on street level. This method was chosen because the urban area had been designed using urban stamps: well-defined block designs that

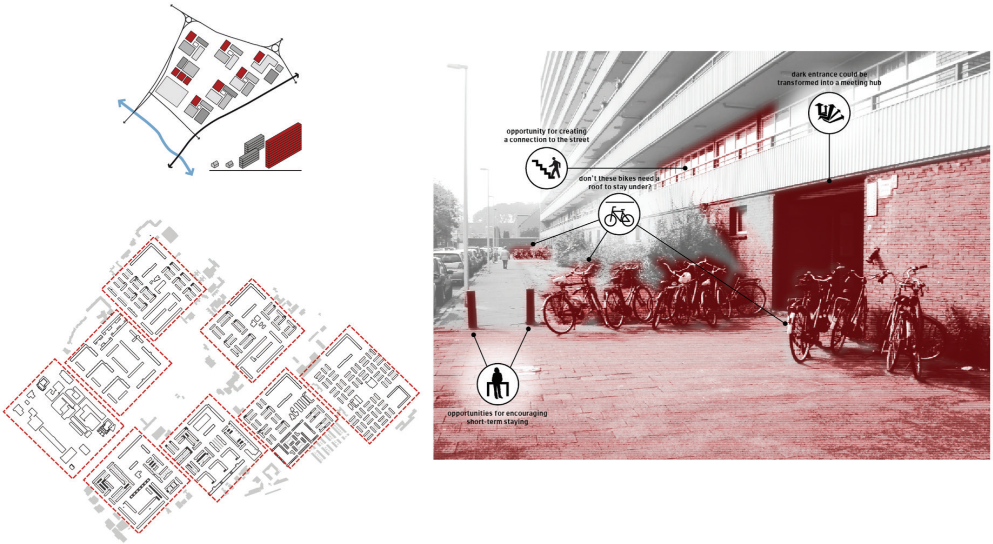


FIGURE 3:

URBAN STRUCTURE OF THE NEIGHBOURHOOD OF OVERVECHT (UTRECHT, NL) WITH REPEATED URBAN STAMPS (LEFT) AND A REGULARLY RECURRING SITUATION THAT NEGATIVELY INFLUENCED THE PUBLIC PERCEPTION: A DARK ENTRANCE WITHOUT SOCIAL CONTROL AND ADEQUATE STREET FURNITURE (RIGHT).

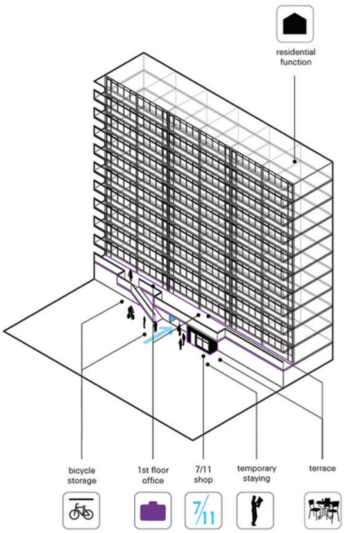
were repeated around a central park. As the stamps were largely similar, situations that led to problems in one stamp often led to problems in the others as well.

By documenting the spatial characteristics of fourteen recurring problem points and identifying how these spots were distributed throughout the urban fabric, we proposed focused solutions to selected architectural problems that jointly influenced the public perception of the neighbourhood. This type of analysis made the idea of a new masterplan superfluous. Instead, we proposed a transformation process that would run for fifteen years, and that started with small, easy-to-solve problems. Over time, architectural interventions became more structural, but were focused on expanding the small successes achieved earlier.

While designing solutions for the recurring problem situations, a broad body of numerical data was used to conceive in outline new interventions that solved multiple problems at once. In the case of uninviting entrances, we proposed having small 7-11 shops near the entrance that could be used by commuters (fig. 4). In addition, we suggested providing stairs to the first floor, adding a direct entrance route that was accessible without entering the building. This decision was made once we realized that many neighbourhood inhabitants ran small businesses like physiotherapy practices, accountancy offices, or hairdressing shops from their homes. By proposing to turn the first floor of each flat into a "business corridor", the number of people passing by the entrance would slightly increase, but just enough to provide more social control and "eyes on the street", in addition to making these businesses more visible and accessible.

In this case, a selection of available demographic and sociological data was used as a guiding theme for formulating design proposals, focusing on the creative recombination of different ideas informed by selected data. The practice of layering and sketching on photographs, as well as visualizing the new situation from a perspective similar to the existing one, provided direct insights into the spatial implications of each design decision. In turn, this method made almost directly clear whether a new decision could plausibly facilitate the changes we envisioned. Not unlike multiple sketches on transparent sketching paper, this method provided feedback through repeated representation.

In a research project titled *Creating Knowledge Through Architectural Design*, we developed the method of situational analysis and design concept formulation. In this project, the focus was on proposing design strategies to reduce CO2 emissions, improve energy efficiency of the built environment, enhance biodiversity, and effectively retrofit existing urban areas from the point of view of urban sustainability.



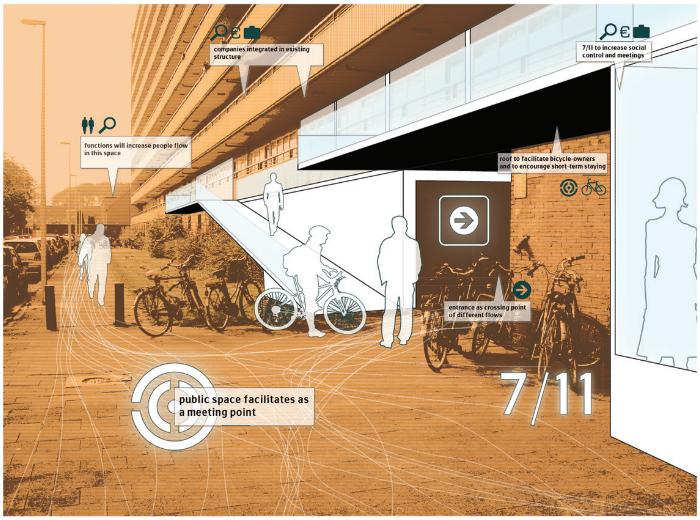


FIGURE 4:

DESIGN PROPOSAL FOR UNINVITING ENTRANCES (LEFT) AND VISUALIZATION (RIGHT).

As discussed, the issue of achieving urban sustainability is often couched in quantitative or performative terms. The ubiquity of digital simulation suggests that in addressing these types of issues, numerical simulation guarantees a maximum amount of control over the problem.

We extended the methodological reach of the situational analysis by mapping recurring situations in two case study areas: Pendrecht/Zuidwijk in Rotterdam (NL) and Hellersdorf-Süd in Berlin (DE). Both areas are post-war urban expansions in need of refurbishment, mainly because the building stock uses outdated isolation materials and heating technology, but also due to their focus on individual, car-based mobility, leading to public spaces that are largely car-oriented.

The situational analysis for these areas was further refined by clearly decoupling observations from consequences and possibilities. For instance, the observation that façades utilizing large glass surfaces enable transparency and visual contact, but also cause swift heating of inside spaces is framed as such, without a further judgement whether this is good or bad in itself (fig. 5). In turn, the glass surface often necessitates air conditioning in summer, leading to increased energy consumption. Given the fact that prefab concrete parts form the basis for much of the post-war architecture and given their thermal properties (like heat trapping), we can conclude that the Urban Heat Island effect, combined with the glass surfaces, leads to an unfavourable indoor climate.

By mapping various observations, consequences, and possibilities for redesigning in an 'architectural catalogue', numerical data and architectural solutions can be coupled and juxtaposed, leading to a detailed understanding of operative architectural mechanisms in the built environment. This knowledge base is essential in proposing well-considered architectural responses to sustainability problems, especially since each intervention leads to new consequences that must be thought through.

This approach provides new pointers for proposing future visions: instead of hoping to solve a multitude of problems with one stroke of the pen, it invites a form of context-based scenario thinking centred around spatial objects, urban arrangements, and their architectural properties.

6) Discussion and Conclusion

The examples listed above share several common characteristics. First, they are focused on spatial designing as method for thinking through architectural decisions. This implies that design practice is irreducibly focused on working in space and evaluating the results of this process as architectural entities that should be conceived holistically.

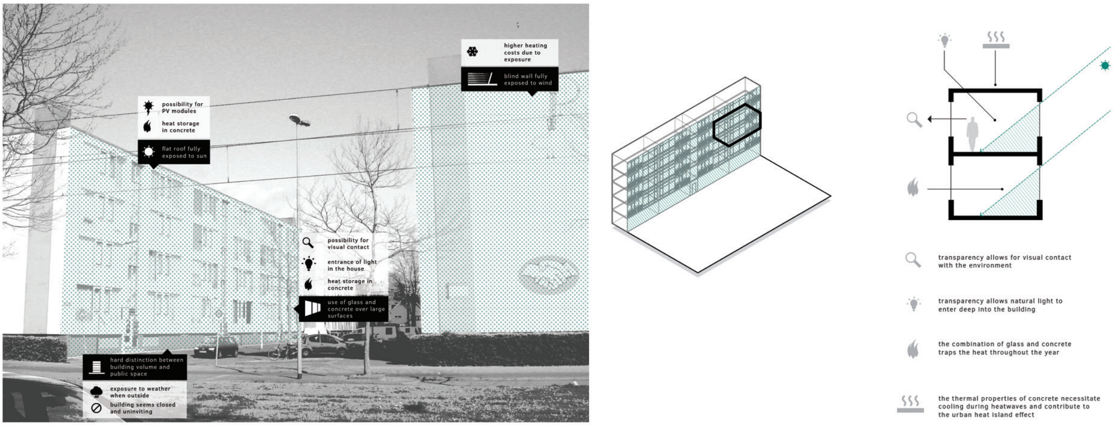


FIGURE 5:

SITUATIONAL ANALYSIS WITH OBSERVATIONS IN THE BLACK BOXES, AND CONSEQUENCES OR POSSIBILITIES IN THE WHITE BOXES (LEFT) AND THE SCHEMATIC CATALOGUE OF OPERATIVE ARCHITECTURAL MECHANISMS (RIGHT).

Second, all examples are projective in the sense that they consider possibilities for redesigning while simultaneously and episodically analysing phenomena, architectural properties, or surveying numerical data. The blurring of boundaries between analysis and design overcomes the distinction proposed by Asimow: understanding or describing a problem cannot be completely decoupled from simultaneously considering new possibilities. These new possibilities are suggestive of possible futures, and make these futures intelligible and accessible to scrutiny, discussion and criticism.

Architectural representation makes ideas, consequences, and spatial qualities sufficiently explicit in an explorative manner. In turn, the resulting ideas become new objects of inquiry. Representation makes architectural ideas discussable from different points of view (fig. 6). Different means of architectural representation highlight specific properties of whatever is being designed, by combining different tools and modelling spaces into a single kaleidoscopic process of questioning and probing. In our experience, this type of representing is irreducibly holistic. It deals with topics like proportions, construction, ecology, economics, and materiality in parallel, but within the confines of a single image or model.

Third, the process of architectural design brings multiple bodies of information together into a single object. During analysis and design, one must shift organically from one body of information to the other. Thus, ecology, material properties, functional patterns, aesthetic considerations, legislative requirements, and construction all come together in one projected future that addresses these issues to some degree. While designing, one must shift continuously between different "mental modalities". Kant's observation that the reflecting judgement is the integrative counterpart of the determining (i.e. exact, subsuming) judgement is remarkably prescient and accurate. Designing is an explicitly integrative activity that creates meaning by utilizing technical, deliberative, non-conceptual and reflective contents, but that cannot be reduced to either one of them.

The tendency to express architectural problems numerically may play an instrumental role in the generation of options, or in optimizing certain features. However, we may ask the question as to whether this strategy deals effectively with architectural objects qua architectural object. It is here that the two assumptions introduced earlier enter the debate again: if architectural objects are viewed as an exhaustively descriptive geometry, then it is tempting to reduce any architectural object to a collection of numerically expressed values. After all, following this logic to its end, such objects are decomposable into their constituent parts, which can be individually controlled.

In view of the challenge of achieving urban sustainability and the interconnected nature of this problem, architectural design must develop

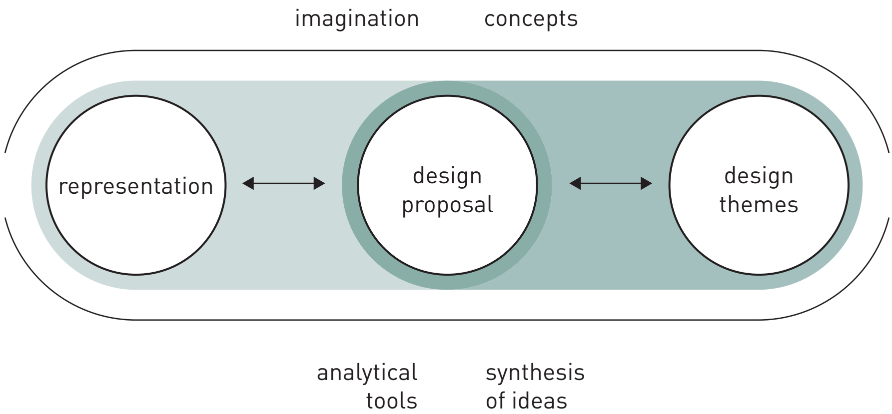


FIGURE 6:

REPRESENTATION AS A DUAL CORE OF DESIGN PROCESSES. THE IMAGINATION AND CONCEPTS REACT ON THE REPRESENTATION, BOTH IN ANALYSING AND SYNTHESIZING IDEAS. THE REPRESENTATION IS SIMULTANEOUSLY AN ANALYTICAL TOOL AND THE RESULT OF DESIGN ACTIVITY. MULTIPLE DESIGN THEMES (ECOLOGY, MATERIALS, FUNCTION, ETC.) ARE SEAMLESSLY INTEGRATED IN THE REPRESENTATION.

models that handle the required level of complexity, without falling into the trap of venturing too far away from its core competence of spatial designing. The examples we discussed change the “order of inference” in design practice, although in a different direction than digital tools currently do. The classical order of inference proceeded by way of externalizing architectural representations that were by nature incomplete and in need of exploration.

The methods discussed here proceed from representing, analysing selected data and architectural results (no matter how tentative) side by side. Drawings, diagrams, sketches, and visualizations are not incomplete stepping-stones towards a result to be built. They are not like Alberti’s representations in this respect. Instead, they serve as probes in a design space of possibilities. Paradoxically, this space does not come into existence if one does not start representing.

Conversely, it is constituted and developed by experimentation. Design representations are focal points for thinking about the implications, limits, and qualities of an architectural idea. The representation is integrative. Every drawing contains elements from different themes that are relevant to the design idea. A single sketch may deal with ecological, technical, and aesthetic properties side by side, integrating them all in a seamless fashion. Such representations can be used as analytical tools (for example to check proportions) but are not reducible to such applications. Every time a representation is viewed, the productive imagination cooperates with the understanding, as the aesthetic judgement emerges through the formalized and traceable properties of the drawing.

The entire space of architectural possibilities is probed through the production and evaluation of a chain (or a cloud) of representations. This allows for drawing of inferences from various representations simultaneously and appositionally. In turn, each inference opens up new questions and options. For instance, it poses the issue whether a certain theme should be analysed in more depth, or how a range of new variations should be developed. As analytical and creative activities both feed into new representations, the architectural “object-to-come” gradually comes into being as a “group of complex relations”.

These relations are complex in the sense that they bridge different domains and give rise to multistable entities. The different— and sometimes incompatible—aspects of such entities are weighed and juxtaposed in cycles of representation, often with the help of visual and spatial means.

By overcoming the distinction between analytical and creative aspects of design, architectural representations function as objects of inquiry in a targeted process that exercises sufficient control over the developmental direction, without assuming that complete control is even necessary or desired for making progress. The methods presented here fully and unreservedly recognize that architectural design is by nature tentative and projective, without having to justify itself on merely quantitative grounds, or the assumption of control.

Indeed, precisely the integrative nature of architectural design proves to be a perfect creative counterpart for the analytical rigour of numerical approaches—provided its methods are well enough developed to take on this role.[49]

The Liminal Dimension

Tacit and Liminal Knowledge in Design Processes

1) Introduction

The notion of “tacit knowledge” developed by Michael Polanyi has an established history in design theory.[50] Polanyi’s catchphrase “we know more than we can tell” has been used to equate tacit knowledge with a type of hidden knowing.

This “hidden knowing” cannot be expressed in concepts or linguistic terms. Consequently, it is often lost in when emotive, affective or otherwise non-conceptual contents are translated into concepts or linguistic expression.[51]

First, despite its distinguished history, we discuss whether tacit knowledge actually provides answers to questions of knowledge accumulation in architectural design. We outline two theoretical problems that the concept of tacit knowledge invites.

Second, we examine some scholarly works on so-called “liminal knowledge” provides a useful and indeed illuminating account of knowledge production in architectural design processes. We provide two different definitions of that term. The first is focused on the limits of what is known, the second on the production of signifiers in architectural design processes.

Third, we maintain that the notion of liminal knowledge avoids the conceptual problems that are inherent in the notion of tacit knowledge, showing the compatibility of liminal knowledge with a few examples taken from design theory.

Fourth and finally, we argue that liminal knowledge provides practical guidelines for architectural design that tacit knowledge cannot provide. We conclude with a discussion of its epistemic status, and sketch in outline how it functions as a driver of architectural design processes.

2) Tacit Knowledge and Its Limitations

The usual interpretation of tacit knowledge corresponds to either of two general interpretations.

Interpretation (1) is closely aligned to the concept of "knowing-how" developed by Gilbert Ryle.[52] Ryle equates tacit knowledge roughly with practical, skill-based knowledge that is hard to codify, as it is contained in performing activities. The only way to grasp is through performance and application. Consequently, speaking or writing about it is not the best way to transfer it from one person to the other, as tacit knowledge cannot be expressed well by using concepts or linguistic expression.

Interpretation (2) holds that tacit knowledge is somehow "implicit" in nature and must be made explicit.[53] In other words, a qualitative shift has to take place in the knowledge itself, one that purportedly transfers it from the implicit to explicit domain.

Interpretation (1) largely follows Ryle's original distinction between knowledge-that and knowledge-how. Ryle made this distinction to combat a paradox in thinking about knowledge. In order to perform action A, it need not be preceded by theoretical knowledge about it.[54] One could intelligently perform an action (for example, designing a chair) without having to consider all that is to know about woodworking, joints and the properties of wood. In order to design, the knowledge regarding the object does not need to be complete. Instead, the designer must possess sufficient level of knowledge to avoid crucial mistakes.

This idea broadly resembles the concept of "unself-conscious design processes" developed by Christopher Alexander. He argued that some design processes (especially those embedded in vernacular traditions) were carried out by practitioners who could not express why they made objects the way they did.[55] The traditional designers possessed a kind of knowledge that "resisted" attempts at formulation, but that could nevertheless be transmitted from one generation to the next. Although the knowledge of the practitioners was incomplete, they could create successful designs.

On interpretation (1), tacit knowledge is a kind of "knowing-how". It is seen as an intrinsically practical type of knowing that cannot be expressed in formulae or procedural descriptions.[56] According to Alexander's view, such practical knowledge is understood as the type of knowing that underlies the transmission of insight from master to student. The student "does not know" what he learns. Consequently, he is unable to describe the rhyme and reason of his activities by using concepts or linguistic expression.[57]

The assumption is that the spectrum of knowledge runs from explicit to implicit, leading naturally from interpretation (1) to interpretation (2). Explicit knowledge be codified in formulae, manuals, guidelines and rules. Implicit knowledge is unordered and undescribed (fig. 1). To make it explicit, it must be described in terms that render it explicit. So, implicit knowledge is present, but without form.[58] This assumption has been entertained for quite some time in management theory.[59] The idea was that companies and individuals alike possessed a type of implicit knowing that could benefit the whole company, if only it were made explicit.

This idea may have its merits as a management strategy, but to apply it to straightforwardly design processes is a category mistake.[60]

The mistake occurs because there are two conceptual problems raised by the notion of tacit knowledge. We shall call them the *semantic problem* and the *expression problem*:

1) *The semantic problem:* How is it that information is first implicit, but can pass a barrier after which it is universally (or at least widely) understandable? Is being tacit only a matter of being difficult to express?[61]

2) *The expression problem:* If making implicit knowledge explicit is merely a way of formulating and codifying it, then tacit knowledge itself is a receding phenomenon. When more and more knowledge is codified, the tacit domain shrinks. Does this mean that there can be a point where there is no tacit knowledge anymore?[62]

The distinction between explicit knowledge and implicit knowledge hinges on the notion of expressibility. We can define this as the degree to which any form of knowledge can be cogently expressed in either conceptual or linguistic terms, whether or not supported by visual or otherwise 2D or 3D spatial representation.

Knowledge with a high degree of expressibility is called explicit because it can be formulated clearly in the form of concepts, rules, rules-of-thumb, blueprints, protocols or guidelines. On the opposite side of the spectrum, we find tacit (implicit) knowledge. This is the type of knowledge that is purportedly at work in design processes but cannot be expressed clearly by using conceptual and/or linguistic means. And if one – like Polanyi – believes that the larger part of the knowledge used in design processes cannot be expressed easily or even at all, it leads one to think that "we know more than we can tell".

The upshot of this assertion is that there is a type of knowing that resists conceptual and/or linguistic expression. One version of this claim can be

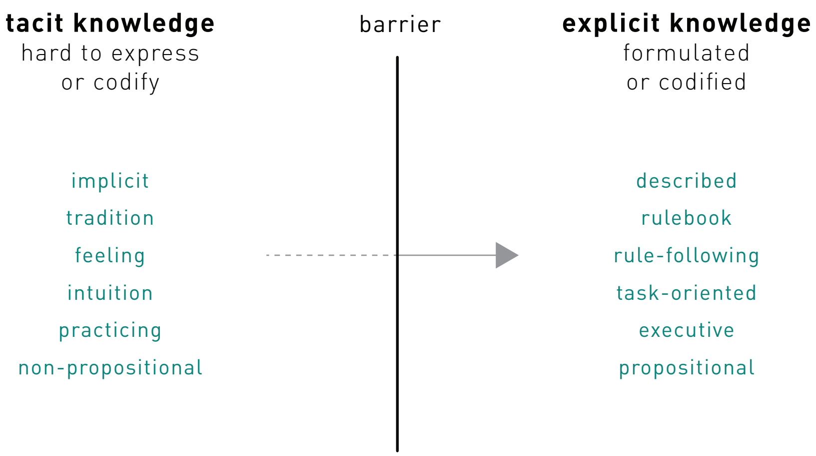


FIGURE 1:

KNOWLEDGE SPECTRUM RUNNING FROM IMPLICIT TO EXPLICIT KNOWLEDGE, WITH A PURPORTED BARRIER IN-BETWEEN THE TWO DOMAINS.

found in a knowledge model developed by Kristina Niederrer.[63] The argument is that "tacit knowledge" is an essential component of research but resists expression in a propositional format (such as broadly reflective judgements, inferentially constructed assertions, inductively or deductively constructed assertions, or any type of assertion that can be used as part of a syllogistic argument). Tacit knowledge is thus seen as non-propositional by nature.

Apart from this statement about the nature of tacit knowledge, we must admit that it is still possible to express facts about tacit knowledge as such. For instance, we can argue that it can be transferred in a situation of cognitive apprenticeship, or that it might be non-conceptually grasped or even emotively experienced. Tacit knowledge itself may resist axiomatic, conceptual or rule-based expression, but it is therefore not necessarily impossible to express it at all. (fig. 1).

One feature we notice in Niederrer's argument is that "tacit content" is understood as an epistemological "surplus". Alternatively, it can be understood as mental content that seems not present in one's conscious or deliberative knowledge about a given topic, but that still exerts a causal influence in design processes. This "surplus" may possibly be expressed, although it requires specific efforts, as mere conceptual and/or linguistic expression is not sufficient.

But expression in some form or the other is supposed to render the "tacit content" explicit. Ideally, this would make the inner dynamics of design processes transparent. But this line of reasoning assumes that there is a type of explication at work in design processes, namely a process of definition. When a design process starts, its aim is to define and determine various contents. The process runs from undetermined to determined. And admittedly, this conception is true in a very general, yet uninformative sense. Indeed, designing may start with a few quick lines jotted down on paper and may end with precise construction drawings. However, this account is somewhat trivial, as it tells little about the relationship between design methods, the type of content that is explicated or expressed and the reason why design representations become more and more precise.

But why do we require explanations that link methods and outcomes? The answer lies in the aim of the question. When examining the dynamics of a design process, we see that questions in one domain (for example, spatial composition) generate new questions and answers in the domains affected by it (for example, construction, materiality and functional programme). The development of a design proposal takes place by bridging and hopping from one topic to the next, often with unexpected leaps and breakthroughs, co-evolving problems and solutions, or periods of stagnation.[64] So, in the most general terms, designing is indeed a way of determining properties of some object or service. However, the process structure of designing is by no means linear or straightforward. In a design process, multiple issues play simultaneously, non-linearly, epicyclically, and interactively. If we cannot formulate the underlying pattern that links methods to outcomes, then design processes are just arbitrary and random. However, if we accept that response as answer, we cannot explain why they can run from undetermined to determined.

And so, merely asserting that tacit knowledge is a "hidden" type of knowledge that can be uncovered tells nothing specific about effectively managing uncertainty or ignorance in a design process. What type of knowledge does a designer need to achieve breakthroughs, to work holistically, to spin the "web of implications"? To appeal to "hidden knowing" or the practice of automated responses is uninformative with regard the twilight domain of knowledge in which designers often work. Summarizing, in this section we introduced two interpretations of tacit knowledge. Both hinge on the idea that there is a spectrum of knowledge that runs from implicit to explicit. However, this idea introduces the semantic and expression problems.

As response, the next section discusses the necessity for providing an account of knowledge at work in design processes that avoids both the semantic problem and the expression problem introduced above. This account addresses also the level of complexity that contemporary designers face, as this is a contributing factor to the uncertainty in decision-making and designing.

3) Controlled Ignorance and Anarchic Nets

In a world that is increasingly interconnected, problems addressed by designers become more complex. It is not possible anymore to have a complete grasp on the issue one is working on. At best, one can say that designers work in the context of the aptly named "Ignorance Society".[65] The modus operandi is no longer to know as much about the design problem as possible, but to control the limit of one's ignorance. Designers must live with the idea that large parts of the problems they work on are uncharted territory, and that there is always something new to analyze. Put differently: Knowledge societies have to accept the idea that they are going to have to always deal with the question of unknown unknowns, that they will never be capable of knowing whether and to what extent the unknown unknowns which they must necessarily grapple with are relevant.[66]

Against the background of increasing complexity, it is explainable why design theorists call for systematic or system-based ways of thinking in an attempt to come to terms with the fact that designers can only influence a small part of the problem they work on.[67]

An illustrative example of a system-based approach (and its limitations) is the notion of "urban metabolism" the idea that cities function like organisms, complete with a metabolism that consumes inputs and generates outputs. Once one analyzes such networks, it becomes clear that there is an endless set of parameters that one could address.[68] However, there is no quick and easy solution to decide where to start, what to do or how to evaluate success. One could be forgiven for mistaking drawings like figure 2 for logistics schemes instead of analytical drawings that deal with architecture. The representation of complexity often does not lead to more clarity, but a visualization of endless interconnections and dependencies (fig. 2).

In a recent monograph, no less that 10 resource streams were identified that could be addressed in order to increase urban sustainability.[69] Even if designers are bombarded with exponentially increasing amounts of data, this barrage does not automatically lead to strategies, let alone good design objectives.

The incompleteness of background knowledge and the continuous information barrage keeps designers in an enduring state of uncertainty, reinforcing the feeling that they need to learn more and more about the problem they work on. With this uncertainty comes the realization that one cannot influence too many factors simultaneously. This applies especially to problems regarding urban sustainability, in which causes, symptoms and effects are so intimately linked that a continuous probing and exploring of options, possibilities and scenarios is required. Now, the point of this probing is not to eliminate ignorance but to control it to some degree.

The conscious incompleteness of knowledge that plagues us now was in traditional societies not known a hindrance. This is because our societies deal with problems of quite a different nature and scope. When the degree of problem complexity increases, the gaps in the knowledge base emerge and become problematic. So, Alexander's concept of the unself-conscious design processes may be accurate for knowledge transfer in pre-industrial societies. However, in contemporary situations, new models of knowledge transfer are needed to deal with the sheer amount of data that must be processed during design processes. This is a problem that traditional societies never faced.

The amount of available data necessitates constant exploration of knowledge that could be relevant for addressing a given design problem. The difficulty of this continuous exploration is that is gives rise to very uneven results, so-called "anarchic nets".[70]

Design problems are networked, branched out and interconnected. Therefore, understanding and ordering the linkages of design problems is a necessity for addressing them. As the systems in which design problems are embedded are complex, the problem must be defined to some degree. But

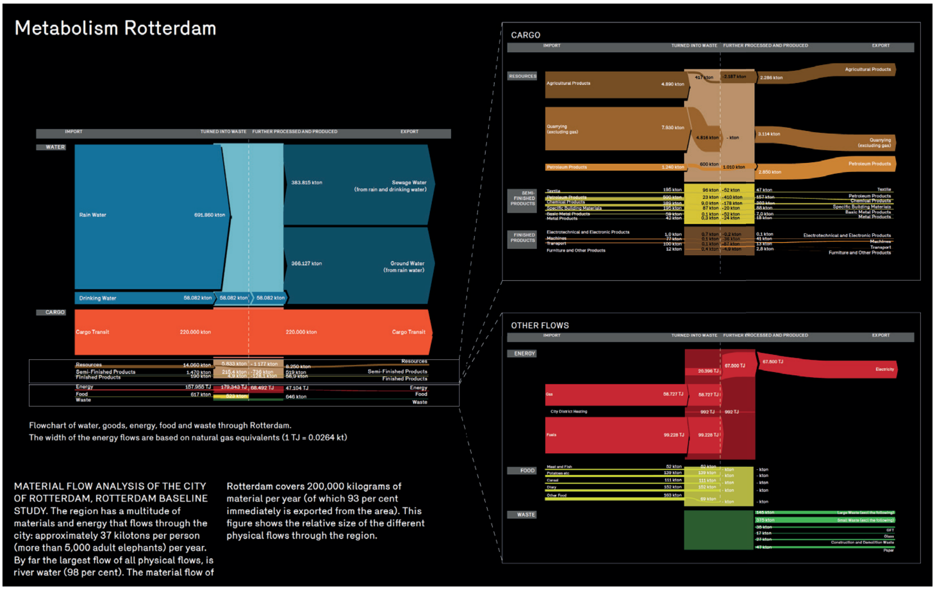


FIGURE 2:

COMPLEXITY AT WORK: A SCHEME DEPICTING THE URBAN METABOLISM OF ROTTERDAM. SOURCE: TILLIE 2014 problem definition is an intelligent, creative and subjective act.[71] Creatively defining the scope of a design problem may contribute to the development of uniquely unexpected solutions formulated under uncertain conditions.

There is always a degree of uncertainty about problem under consideration. To deal with complexity, designers assemble various sources of information. This information is not only derived from secondary sources, but also from artefacts produced during the design process. This kind of information gathering is a-disciplinary in the sense that its contents cannot be classified under one or two determinate categories. The "knowledge net" that designers spin contains various types of knowledge, embodied in different media, linked by connections that may or may not be stable. It is not possible to say in advance whether a theme neglected in preliminary analyses will not introduce problems later on. This unpredictable feature of knowledge nets is worsened by the fact that the human brain easily postulates causal relationships. However, those causal chains do not describe reality in all its fullness. As tool of comprehending complexity, mapping causal connections do not suffice, as the incompleteness that of the knowledge base is also a problem here.

Moreover, if we map causal connections (let's say, we postulate that the water drainage system of a public space causes flooding of the parking garage and the deterioration of the planting), we require once again concepts to formulate the causal chain itself. So, any form of inductive, deductive or inferential reasoning is heavily dependent on explicit knowledge and/or concept possession. However, if a large portion of the relevant information is in fact implicit, this knowledge cannot be incorporated in the reasoning process. So, to think of design processes as being merely reasoning processes that explicate information leads again into a dead end.

So, contemporary design problems are highly complex, and designers must necessarily deal ignorance and uncertainty in addressing them. The model of "anarchic nets" explains why design problems are networked and lack a clear hierarchy.

Against this background, we propose to view the working space of designers first and foremost as a learning space – a place of (personal) transformation and perpetual reconstruction.[72] To characterize the knowledge at work in design processes, we discuss first two definitions of "liminal knowledge" and its characteristics.

4) Liminal Knowledge: A Theoretical Characterization

The term liminal knowledge is derived from the Latin *limen*, meaning "threshold".[73] It describes a type of knowledge produced in an epistemological twilight zone and that is accumulated by passing successive thresholds or transformative moments. In such moments, the situation one is working on is understood differently, and the understanding subject himself is also transformed.[74] Such "learning zones" are for instance design experiments where the goal is not completely clear, or where there is a certain degree of uncertainty about the usefulness of the outcomes. In such experimental situations, either the direction of the process or the results may be surprisingly innovative or may misfire completely.

More precisely defined, liminal knowledge is "(...) knowledge at the edge or periphery of phenomena or objects of interest, things that seem irrelevant or secondary. Thus, an emphasis on the exception rather than the rule, on the indeterminate rather than the defined."[75] This is not non-knowledge, but a latent consciousness about the boundaries of one's current knowledge base. Yet, this insufficient amount of knowledge must suffice to formulate design proposals and solution types.[76]

Knorr-Cetina describes how the discipline of high-energy physics (HEP) harnesses this knowledge about one's limits:

> *High energy colliders physics [HEP] defines the perturbations of positive knowledge in terms of the limitations of its own apparatus and approach. But it does not do this just to put the blame on these components, or to complain about them. Rather, it teases these fiends of empirical research out of their liminal existence; it draws distinctions between them, elaborates on them, and creates a discourse about them. It puts them under the magnifying glass and presents enlarged versions of them to the public.*[77]

This description comes from the domain of physics, a research domain with different rules, norms, and experimental set-ups. Yet, the main point in this passage is clear and applicable to design activity as well. Lack of knowledge can be harnessed as a tool just as the presence of knowledge can. We can see this by comparing the commonalities of HEP and architectural design. This common area is the correction of errors in intermediate experiment results.[78] In the continuous change and adaptation of experimental outputs (in the case of architecture, drawings, models, sketches...) the liminal approach is at its most effective.

For instance, the idea that designers work with artefacts that incrementally express the embodiment of an underlying concept of idea can be readily traced to working with limited knowledge. Every artefact in a series is constructed with the help of a insufficient knowledge base. The artefact by itself does not suffice to solve a problem or bring the components of a problem together in a satisfactory manner. In his documentation of a design experiment in which subjects had to design a post office, Goel describes how the test subjects first explored the boundaries of the "space of possibilities" by asking questions to the scientist monitoring the process.[79] Questioning and probing is a way to

To deal with complexity, designers assemble various sources of information. This information is not only derived from secondary sources, but also from artefacts produced during the design process. The notion of "anarchic nets" explains why design problems are networked and lack a clear hierarchy.

During later stages of the design process, the narrative explaining the internal logic of an artefact becomes increasingly coherent, more context-driven and fills up with semantic content. Every piece of the puzzle falls into place, as it were. This coherency provides the designer with strong reasons to defend his proposal.

collect more information to address a problem. So, this experiment provides some support for Knorr-Cetina's description of turning the absence of knowledge into an advantage. The designers in the experiments knew fully well that the information at their disposal at the beginning of the process did not suffice for formulating a solution. By searching along the edges of the space of possibilities, a set of rough boundary conditions emerges – the minimum requirements that a design proposal must fulfil.

The correction of earlier errors and shortcomings by working out new options is an integral part of architectural design processes and has been well documented.[80] This process has two directions.[81]

First, the search moves laterally through the space of possibilities, developing main variations of possible solutions. In this explorative stage, commitment is limited; options may be easily discarded and changed.

The second phase is characterized by a vertical exploration: one option or promising alternative is developed in-depth, producing a range of variations on a single option. Alternatively, when this search does not coalesce into something useful, the lateral exploration is taken up again. Or, once again, alternatively, the in-depth search can be combined with results from earlier exploration cycles, ending up in new options that hybridize and superimpose ideas (fig. 3).

During the second stage, the designer becomes increasingly committed to his proposal. It has achieved a certain coherence that can be expressed in relatively clear terms and can be defended with arguments.

The processes of lateral and vertical exploration serve a double goal. First, they are heuristic devices. Among an impossibly large set of options, they are used to quickly generate promising alternatives that allow further development. This development leads over time to a complete design proposal– but accomplished with incomplete knowledge.

Second, this process structure creates a body of relatively coherent assertions about the artefacts that are being produced and the ideas of which they are expressions. The limited commitment in the early stages of a design process can be explained by the fact that there is a lack of reasons to get too attached to a single option. Among the options, there are few explicit grounds to favour one over the other.

During later stages of the design process, the narrative explaining the internal logic of an artefact becomes increasingly coherent, more context-driven and fills up with semantic content. Every piece of the puzzle falls into place, as it were. This coherency provides the designer with strong reasons to defend his proposal. By careful development and reasoning, the

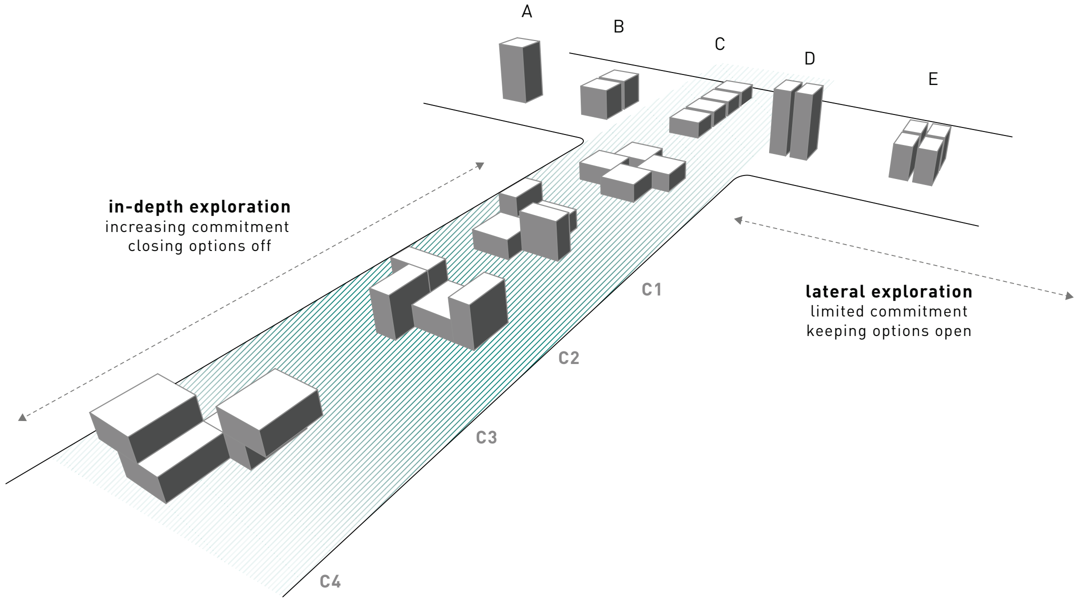


FIGURE 3:

LATERAL AND VERTICAL EXPLORATION OF THE SPACE OF POSSIBILITIES. SOURCE: AFTER GOEL 1992: 849

artefact is gradually pulled in the space of giving reasons. This process of "discursivation" makes implicit assumptions explicit through an interactive process of making, reasoning and arguing about the merits and shortcomings of a design proposal. Like the physics experiments in the example, the discourse surrounding the artefact is created in interaction with the artefact itself. Once a design idea becomes tangible in the form of representations, it can be discussed, and a discourse can be created around it.[82] Discursivation is the creation of reasons and inferences that takes place through designing artefacts, questioning them, analyzing them and changing them if the reasons for their appearance and properties are found lacking.

Pirolli documents a straightforward case of such discursivation. In an experimental setup, participants who had to design a new cash machine utilized a technique known as scenario immersion. By imagining themselves as users of the cash machine, they defined some basic rules for the design.[83]

Moreover, the participants listed characteristics of several cash machines that they wanted to avoid. The negative identification ("I wish to avoid characteristic X or Y") led to the formulation of new design ideas. In both cases, the knowledge with which the designers worked was incomplete. Yet, by combining existing sources and recombining them, a new direction of thought or angle of approach emerged. The features to be avoided were clearly spelled out and became an integral part of reasoning and decision processes.

We find a similar discussion of this process in Polanyi's *Personal Knowledge*. Polanyi distinguishes between three types of learning: trick learning, symbol learning and a combination of the two, which he calls implicit learning in some places and inarticulate learning in some others. Here, again, the description closely echoes the ideas of lateral and vertical exploration:

> *The first, irreversible phase may be one of systematic exploration, resulting in the gradual building up of an interpretative framework, but it may also be merely a puzzled contemplation of a situation, leading to a solution in a flash of insight. Again, the amount of ingenuity contributing an irreversible coefficient to the conceptual operations of the second phase, may vary considerably. Yet in spite of this we may distinguish also in case C, clearly enough, between an act of insight, which is irreversible, and the resultant performance, which is comparatively reversible.*[84]

Each decision might generate new information and may lead to new, undiscovered possibilities, thus driving the discovery process. So, the designer must decide which direction to follow but cannot clearly see (all) consequences of his actions. His knowledge is impaired by multiple factors that play their part in the quality of the design proposal and by his own immersion in the process. This is called "epistemic dissonance".[85]

Epistemic dissonance is not necessarily negative. When utilized strategically, it helps designers to make better decisions and open up new options. An ethnographic study suggests that different stakeholders in a design process project their requirements on design proposals, leading to a process of negotiation.[86] This leads to compromises, hybrid solutions and settling differences, as well as a temporary suspension of judgement instead of jumping towards the immediate solution of problems.[87]

Friction and the constant need for making provisional settlements are productive forces in the design process. While the negotiations may occur between multiple persons, an individual designer working on a proposal must perform these disputes on his own. The friction between various viewpoints is productive. It generates new insights and alternatives, preventing designers from becoming too attached to a single viewpoint.

For instance, sometimes an employee in a design office looks at a poster or model for a project that will shortly be presented and starts thinking aloud. His colleagues join in and a group discussion ensues. This type of conversation (with the situation) has a very specific character. Its goal is not to communicate or coordinate, but it is geared towards a collective expression of impressions, ideas, directions of thought or doubts that are being provoked by the object, be it a drawing, sketch or model.[88] This collective action leads to a comparison of different viewpoints and rationalities that stimulate the formation of new possibilities and alternatives.[89]

So, liminal knowledge is the knowledge of the limits of one's actual knowledge. In turn, this realization leads to the invention of strategies that recombine available sources into minimally coherent solutions and proposals. Lateral and vertical exploration of options, discursivation, negotiation, and epistemic dissonance are strategies to utilize the lack of tangible knowledge in design processes. These strategies cannot function without representation, as they hinge on the drawings, sketches, models etc.

5) Liminal Knowledge in Producing New Signifiers

The notion of liminality has been developed to theorize how the understanding of designers transforms during the explorative phases of design processes. This transformation is based on the intimate link between making and understanding. There is but a minimal gap between the thinking action and its physical action it sets in motion.

This intimate link between the mental and the material is so tight that it can be described as "thinking through drawing".[90] It follows that the thinking process of architectural design is inextricably coupled to representation. In linguistic terms: the production of signifiers. Such signifiers are intelligible symbols or placeholders for ideas, concepts or technical content. They allow for creating a discursive space – a space where the participants exchange reasons, impressions, and ideas. Or, put more concisely:

> *Any encounter with troublesome knowledge in the liminal space will have a discursive characteristic. It will involve encounters with new signification and attempts to derive meaning from symbolic representation, linguistic, mathematical or visual.*[91]

Often, new ideas and concepts cannot be expressed adequately with existing signifiers. Therefore, the expression of new concepts or ideas often goes hand in hand with the creation of new signifiers or forms of representation. This is especially relevant for architectural design. A design idea is often probed and investigated by creating representations that make its unique properties intelligible. Such representations are signifiers that tell something about an idea that is only dimly known at the outset of a design process. This process is roughly accumulative:

> *Changing the signified changes our perception of the signifier and can cause us to identify new signifiers for the concept in different domains i.e. the integrative effect. This effect is accumulative and gradually affects our perception of the whole world around us and hence how we fit in that world.*[92]

This integrative effect changes the designer and the understanding of what is being designed. Through successive cycles of representation and, an object is reconstructed from different viewpoints and through different visual media. Consequently, the liminal dimension is a "liquid space", where every change in understanding creates ripples that influence the understanding of the artefact or situation as a whole.[93] (fig. 4).

Understanding is never an isolated phenomenon. It exerts its effects beyond what is immediately changed or reconstructed. This can be readily seen in the way designers use and recycle ideas throughout the design process:

> *As interim design ideas or solutions are generated, they are retained, massaged and incrementally developed until they reach their final form. Very rarely are ideas or solutions forgotten or discarded. In other words, information about the state of the design, and associated knowledge brought into the design problem space, appears to increase in a monotonic fashion throughout the design process. This is one of the most robust findings in the literature on problem solving in design.*[94]

Differential repetition and reconstruction in design processes serve to experiment with individual properties that can be changed, retaining those that are valuable.[95] The more artefacts are being produced, the richer the set of possible comparisons becomes.[96] Because design proposals (especially architectural designs) are rich and multi-layered entities, comparisons can

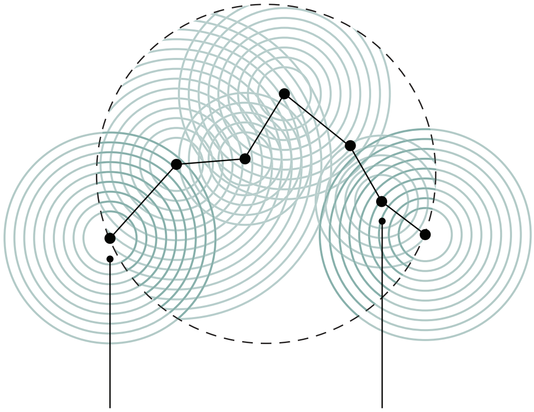


FIGURE 4:

RIPPLE EFFECTS OF INDIVIDUAL DECISIONS. EVERY PROCESS STEP IS CONNECTED AND INFLUENCES SURROUNDING POSSIBILITIES.

be drawn at multiple levels, allowing designers to organize their knowledge by means of visual representations. Again, we find this thought expressed in Polanyi's work on what he called "the logic of achievement":

> *A big step towards the generalization of the powers of thought downwards in the direction of morphogenetic originality is made by acknowledging the originative powers of unconscious thought. The unconscious exercise of originality is usually still prompted by a conscious effort and a judgment of a high order, as in the case of the heuristic efforts which induce discovery during a subsequent period of latency.*[97]

Fragments of ideas and partial solutions are often retained in the unconscious, only to "pop up" and re-assert themselves during a later stage. But in the realm of conscious, deliberative thought and active learning, an effort must be made to keep the various pieces of an idea moving. In doing so, the liminal space comes into being. To create a drawing or a model is not just to create a representation, but to involve those factors that we did not know we already possessed, but that are "latent" in our subconscious. What we often see as "original" is shot through with old and new ideas. We see it as a discovery, only because we forgot how much we already knew, or did not realize in what ways an artefacts is suffused with knowledge and insight we already possessed.

Not coincidentally, then, liminal knowledge emerges through the creation of open-ended objects that enable interpretation, comparison and reconstruction.[98] Comparing and evaluating of these artefacts creates gradually an organized knowledge base that is visually represented. New forms of representation stimulate more accurate expression and a richer understanding, enabling the designer to become intimately familiar with the proposal he creates, and communicating its value to others.

6) Conclusion: The Epistemic Status of Liminal Knowledge

Combining the definitions of liminal knowledge discussed above, we can say that it is not a new type of knowledge, like "knowing-how" or "tacit knowledge". It is not a categorization of a way of knowing that is new or different. Instead, it is the product or by-product of design practices that are centred around objects and representations. Ryle's concept of "knowledge-that" can be characterized by the general proposition: "I know that X is the case" or "I know that X".

An example from practice would be "I know that for this size of construction, I will need beam with a minimum size of...". In this case, facts about constructive properties can be easily combined and achieve a status of near-certainty. Tacit knowledge can be characterized by the assertion: "I can know X by carefully paying attention to Y and Z". An example from practice would be: "Given the geography and the site, and the expected behavior of the planned vegetation, I expect that in five years a fully functioning biotope develops here". In this case, estimates and facts are combined into compound predictions or conclusions that need explanation if outsiders are to understand their plausibility.

Liminal knowledge functions slightly differently. It has a provisional structure, which can be characterized with the following formula: "Every time that D manipulate artefact X, D derives some new insight Y that he can use to re-construct the subject matter he works on". The manipulation of artefacts in architectural design processes enables "retaining, massaging and incrementally developing ideas" over an extended period of time. The development of a design idea progresses through reconstructing an idea through representations. In design process models, reconstruction is often goes confused with name "evaluation". However, this term is slightly misleading, as the norms of evaluation evolve with the artefact itself. The criteria for evaluation are often not even clear at the outset of design processes.[99]

The sequence of operations in a design process is the deliberate creation of a discourse. This is a "space of reasons" that surrounds artefacts, prototypes and intermediate proposals in development.[100] This discourse is embodied in discussions, sketches, notes, models, drawings and simulation outcomes. Taken together, such collections form a documentation archive the shifts in understanding the original problem, the responses to it and the norms used to evaluate it.

Liminal knowledge accrues around provisional insights (that may be true or partially true) that open new ideas and possibilities for further development. The mode of knowing associated with liminal knowledge can therefore be characterized as a type of open-ended, experimental attitude that reasons as follows: "Given insight X, it might be useful to try out options A, B and C, and see how they play out relative to the original problem definition". The focus of this approach is not on archiving knowledge, but on actively creating and applying it.

The two theoretical problems introduced earlier (the *semantic problem* and the *expression problem*) are avoided by considering liminal knowledge as a primary driver of architectural design processes.

The account of liminal knowledge as sketched here avoids the semantic problem by rejecting the distinction between two types of knowledge that are qualitatively different. It rejects also the transition between them, rendering the question of how to transform implicit knowledge into explicit knowledge obsolete. Instead, liminal knowledge can be regarded as a "given", a simple primitive fact about the reasoning processes of designers. Insights resulting from working with incomplete knowledge and visual representations are not always clearly spelled out. Often, they are open-ended, but they are not necessarily implicit, or hard to codify.

The expression problem is avoided entirety if one conceives liminal knowledge as a driving force of the design process. The question if a “tacit component” will remain after everything in a design process has been expressed is rendered meaningless as soon as one rejects the implicit/explicit distinction altogether. Instead, it is the tapestry of incomplete expressions that provides an epistemically “kaleidoscopic” overview of options and possibilities that can be worked out in various directions.

Contemporary complexity asks for knowledge models that deal with a presence of ignorance that is structural instead of accidental. The condition of “epistemic dissonance” has permeated architectural practice at large. The introduction of liminal knowledge as a driver of design processes shifts the focus of conceptual questions regarding representation and its epistemic effects towards an organization of knowing.

The outline we provided is a mere sketch, and much more could be said about liminal knowledge. For instance, about its relation to decision-making in design processes, its value in educational settings, or its generative relation to denotative representation. However, we hope to have drawn attention to the merits of this concept in the context of understanding and improving design processes in the contemporary context of complexity.

Drawing as Notational Thinking

Notation and Design Cognition

1) Introduction

The traces and marks left by pencils and styluses (and more recently on computer screens and tablets) play operative and explorative roles in architectural design processes. Drawing serves to develop architectural ideas, forming an indispensable part of architectural thinking processes.[101]

Some forms of drawing are forms of notation that exhibit potentials as cornerstones of design-based thinking. Their potential is inextricably bound to notating.

Their usage as design tools for developing ideas cannot be decoupled from the fact that it is a practice of materializing thoughts through the practice of purposive notation, or of inscribing traces on a surface in a directed, embodied process that is intrinsically entangled with its object.[102]

Given this reliance on notation, the aim of this paper will be an attempt to rethink of the concept of notationality as developed by Goodman to conceptualize the link between notating and its role in knowledge production in architectural drawing in a way that is tailored to the discipline.[103] This seems necessary in view of two developments.

First, a renewed interest in notationality in conjunction with the idea of operativity in design processes.[104] Second, because Goodman had many worthwhile things to say about notational practices, yet left the topic of notation in architectural design processes largely undeveloped. We can only guess why this is so, but it leaves us in a situation where the relations between drawing and notating are left somewhat undefined, or even oversimplified.

By explicating how Goodman conceived the relation between idea and notation, followed by a proposal to rethink his conception of notationality in a new direction, the case is made that architectural design is a form of thinking that is closely bound (yet not reducible to) notational practices. However, this account deals with notationality in a slightly different sense than Goodman originally imagined. Moreover, Goodman overlooked precisely those aspects that make notationality important for contemporary architectural practices. This claim is substantiated by reviewing various ideas and concepts by Michel de Certeau, Sybille Krämer and Peter Zumthor.

2) Notationality: the relation of content to notation

The concept of notationality derives from the aesthetic theory of Nelson Goodman.[105] Informally, the term refers to the degree to which artistic performances can be noted down in a notational scheme with a high degree of exactitude. Thus, a score of a Bach cantata or the written choreography of a dance is notational: it can be represented with the help of signs and can be read afterwards; it can be performed multiple times by referring to the written sequence of signs. Each time the cantata or dance is performed is an instantiation of the score or choreography.

Put differently, the score or choreography is a type that determines which performances are tokens of the instructions set down in writing. A performance that misses essential features cannot be said to be that specific cantata or this specific dance.[106] So, the score determines how we should judge the performance – if the gap between instruction and instantiation becomes too wide, the relationship between the two is obliterated. Originally, Goodman introduced the concept of notationality to distinguish between autographic and allographic works of art, shifting the emphasis of the discussion towards the relation between the type (the original) and the token (its performance or instantiation).[107]

Formally put, the term notationality is a stringent condition for symbol systems or schemes. The aim of this condition is to specify precisely how a notational scheme or system might be translated to a performance and back.[108] Thus, a set of symbols that possesses perfect notationality can be used as basis for a performance (for example, as a cantata). Conversely, the performance can be used for writing a series of symbols that allows for a second, qualitatively identical performance. Goodman applied this distinction to architectural design, leading to the question to what degree drawings or sketches could be understood as a token of an original thought.

Goodman held that notationality applied not only to performances that can be readily described by notational schemes or systems, such as scores or choreographies, but that it also could apply to sketches and paintings. Of course, he remarked that sketches are different and less defined than musical scores:

> *Thus, whereas a true score picks out a class of performances that are the equal and only instances of a musical work, a sketch does not determine a class of objects that are the equal and only instances of a work of painting. Unlike the score, the sketch does not define a work (...) but rather is one.*[109]

This description of the sketch is closely aligned with Goodman's discussion of painting, where the same problem surfaces: the musical score or the choreography is an ideal example, and is expressed in a clear, indicative signs. Although the score does not determine everything about the performance (its expressiveness, for example, is more hinted at than completely described by terms like *allegro, con moto* etc.), its formal appearance and the use of individual symbols is unambiguous. Notes are notes, and steps are steps in these ideal languages. Visual language is in this sense more complex: it does not consist of discrete units (like notes, letters or symbols), and while Goodman discusses how one may consider a painting as a class on its own, the original problem remains: there is a fundamental ambiguity regarding the notation and the work in painting.

The problem is one of identity: the painting does not refer to a prior score or script, and each attempt to remake it does not rest on the interpretation of a symbolic language, but on a direct performance. One has to paint to replicate a painting, while someone does not have to compose in order to re-perform a cantata.

When we consider sketches in the context of an architectural design process, the problem introduced by Goodman deepens. First, many sketches are not clear, unambiguous instructions in a predefined visual language. Second, there is no formal condition that states that a visual language is structurally akin to a verbal, linguistically or gesturally structured language. Third, architectural design processes are comprised of multiple visual languages superimposed on each other. Quick scribbles and thoughts that are jotted down may be a-temporal, even a-spatial ideas.[110] They are ambiguous in character, making it hard to consider them as a score, script or choreography. We can formalize the difference between written and visual language by saying that all signs used in the former are *indicative*, while some signs in the latter are *expressive*. Indicating a sequence of notes amounts to instructing; expressing the outline of a building with a single stroke of the pen is more than just indicating. It expresses an idea that later on has to be refined by using indicative signs.

Consequently, the contents of a technical drawing are fully determined. It is composed of technical, indicative signs that clearly and unambiguously communicate its meaning. Dimensions, materials, and symbols play utilitarian, practical roles in such drawings. On the level of notation, technical drawings used to realize architectural objects have more in common with a script or a musical score than the conceptual drawings early in the design process:

> *In that architecture has a reasonably appropriate notational system and that some of its works are unmistakably allographic, the art is allographic. But insofar as its notational language has not acquired full authority to divorce*

> *identity of work in all cases from particular production, architecture is a mixed and transitional case.*[111]

It is here that Goodman skips a step as it were, leaving the variety and different roles of architectural drawings largely undiscussed, calling architecture broadly 'mixed and transitional', while abstaining from clarifying how different media, expressive and indicative signs, notational systems and performance are distributed in architectural design processes. Exactly this gap in Goodman's provides an opportunity to reflect on the role of notations in architectural representations, and to augment them to suit architectural practice.

In-between the radical ambiguity of early sketches and the determined, anatomical character of the final drawings of an architectural design process exists a conceptual twilight zone in which various types of visuals overlap and interact, and in which the practice of drawing plays a pivotal, developmental role. In a sense then, architectural drawing is a form of notation, but it is a vastly different form than the script or the musical score. Instead, in architectural design processes different forms of notation come together and overlap.

The question that Goodman poses ("is a work repeatable by relying on its notation?") is not directly applicable (or even relevant) to architectural practice. Instead, the drawing is an integral part of the creative process that gives rise to realized architecture. Although it is possible to build the same building twice, it does not follow that therefore every architectural drawing is a kind of musical score to which Goodman's criteria of notationality must apply, nor is it the case that an autographic work should be a one-off affair. Instead, the situation is often the other way around: drawings deal with a specific context and a specific architectural assignment that cannot be divorced from the final, built result.[112]

To do justice to architectural drawings the relation between the notation and the built (or unbuilt) result needs a different account in order to be applicable to architectural design processes. Two main reasons can be noted for this necessity; first, architectural drawings, models and artefacts are not only intended as instructions for realization – they contain indicative *and* expressive signs. Second, they embody a multitude of insights that are not reducible to linguistic structures and cannot be judged solely as series of symbols – although such symbols form much of the content of the drawing. If Goodman's account should be criticized on fundamentals, his reliance on symbol systems and their semantic and syntactic properties to clarify processes in domains where these properties have limited applicability should be considered as a prime candidate. The linguistic model works well for certain symbol sets and applications (for example, mathematical symbols or the alphabet), but only limited in the case of drawings and images in a broader sense. It is at this point that we may need to leave Goodman's approach behind and look for different ways to augment his argumentation with regard to images and drawings.

Notational systems are utilized during architectural design processes in ways that are notational, yet of a sort that is not reducible to Goodman's model. In turn, the epistemic potentials of such systems are dependent on such purposive notation. We develop two concise themes here: first, the relation between notation, iterability and signs; second, notation and the experimental space it provides. These themes allow us to augment and complement the useful features of Goodman's account with selected concepts to make the concept of notationality relevant to contemporary architectural practice.

3) Notation, iterability and signs

When one draws to design something, either a building, neighbourhood or logo, one is confronted with absence: the object under construction exists only as a promise, as a vague mental image maybe. Although it is absent in its physical form, its promise structures the inquiry. The absence of the object is not just a simple lacking, a generic non-presence. It is an absence of a specific type:

> *Since every absence, whether in the language of action or in articulated language (...) presupposes a certain absence (to be determined), the absence within the particular field of writing will have to be of an original type if one intends to grant any specificity whatsoever to the written sign.*[113]

Derrida's claim here is very precise: the signs and traces that emerge as reaction to an absence match it, like a puzzle piece that matches an empty slot. If we apply this thought to architectural design, the drawing process is not just a matter of imitation, of denoting a mental image that is by and large finished, but it is a precise response to a precise absence. The first conclusion to be drawn here is that denotation is not the goal of a representative process: the idea is explicitly not to create images that resemble a ready-made 'image in the head'.[114]

Instead, the precise absence forces designers to respond in ways that are clearly matched and oriented towards the subject matter.

Drawing is a way to represent various qualities and properties of the absent object, hauling it step by step into the physical world. While it is certainly true that architectural drawings can be used to "test or "refine" the properties of the depicted object in a simulated environment, such an account would be overtly reductive.[115] Drawing is as much constitutive as it is explicatory. It materializes an idea, and as such makes it "present". If anything, drawing negates the absence that Derrida speaks about – it brings a new "presence" into the world. Architectural conceptions are made literally present through notation (or, alternatively, inscription or tracing). In design processes, such acts of notation are drawing or modelling. The qualities that are being drawn or the objects that are being modelled do not pre-exist somewhere, waiting to be released. Instead, their qualities have to be uncovered and created at the same time. This process rests on a very specific type of repetition that works through notation. Sketches and ideas are reworked over and over again, re-iterating and refining a concept, thought or idea.

An example of this practice can be found in the work of UNStudio. Van Berkel and Bos utilized diagrams that described the structure of design proposals on a very general level. These diagrams condense information in an organized, yet flexible manner. Van Berkel and Bos note that even before thinking of practicalities, the diagram shows what is happening at a certain location.[116]

Since every architectural project is embedded in its own, singular context, UNStudio developed customized diagrams tailored to the needs of individual projects. They noted that after a few years, certain diagrams re-appeared, and that this repetition led to a more precise and focused level of inventiveness. This type of repetition is different from just replicating the same solution in a different situation. Each repetition is simultaneously a further developmental stage of an existing knowledge base and a new adaptation to a unique architectural context (fig. 1).

Diagrams unite serial production and combinatorial freedom. Each diagram is uniquely tailored, yet thematically, visually and organisationally linked to its predecessor and to its descendant. Yet, by combining and recombining elements in the diagrams, something genuinely new emerges through re-iterating a similar methodological gesture.

The concept of iteration is closely related to the theme of re-performing: iterability connects repetition to alterity, and similarity to novelty.[117] We can observe this in the familiar scene of designers drawing a plan over and over again, only to change little details with each new attempt. In each new version, a new alternative future unfolds, even though it might be hard to distinguish it from the versions that immediately precede and follow it. Every form of notation has this potential to some degree. Both in reading and writing, generative repetition occurs. Every time a sign is written, or a drawing is made, something genuinely new emerges from out of the lines and marks.

This repetition or re-performance is needed to reach the desired level of alterity (variations centred around a few themes) at all. It is a necessary condition for novelty to emerge at all. Naturally, this introduces the question why this should be so.[118] We find some clues in the concept of *differential repetition*, pioneered by Hans-Jörg Rheinberger. Once an act of representation is repeated, we are not just dealing with the serial production of the same representational content, but with an act of differentiation within a given domain of representational content. The representation itself opens up and reveals with each iteration to which adjacent ideas and themes it can be linked.

First, we should therefore note that the repetition we encounter here is not necessarily the same as in the case of performing the same cantata or dance twice – the performance is not a token of an ideal type.[119] The repetition in architectural design processes is of a different, and importantly generative character. The reason why architectural representation harbours this possibility may be ascribed to the versatile mix of indicative and expressive signs it utilizes, and the roles that they play in architectural thinking.

The mixture of signs that constitute drawings is composed of peculiar elements in the sense that they combine seemingly paradoxical and contradictory qualities. They are highly abstract, depicting the bare minimum of an idea, sometimes only alluding to some of its qualities through sheer expressiveness. The concept sketches of Frank Gehry come to mind – a few lines depict a general compositional principle, the details of which are not directly derivable from the drawing itself. Yet, the expressive character of such sketches is undeniable, opening up a dimension that indicative signs can hardly touch, and may even forever fall short of approximating.

Such expressive sketches catch an architectural essence with minimal means. They serve as a point of reference for reasoning and further development during subsequent design steps. Consequently they combine a minimum of semantic content with a maximum of artistic expression.

A different form of abstraction can be found in Ludwig Hilberseimer's 1927 plans for a *Großstadtarchitektur*, his 1944 proposals for a "New City", or O. M. Ungers' 1977 *Die Stadt in der Stadt*, although in this case it is an abstraction with regards to level of detail, not so much with regards to spatial composition in the narrow sense.[120] The organization and spatial configuration is present, but it lacks any detailing on how it could practically function in everyday life

Yet, these images add a level of plausibility to a possible future scenario due to their sheer visionary and structural approach. De Jong calls this the creation of *bestaansvoorwaarden* or "necessary conditions for existence".[121] The overall coordinates of an architectural idea are expressed with a high degree of abstraction or generality, yet their clarity stems not from the presence of details, but from the tangible evocative power emanating from the notation itself.

Put differently, architectural drawings combine the *formal and indicative* qualities of notational systems with the *expressive* power of artistic practices.

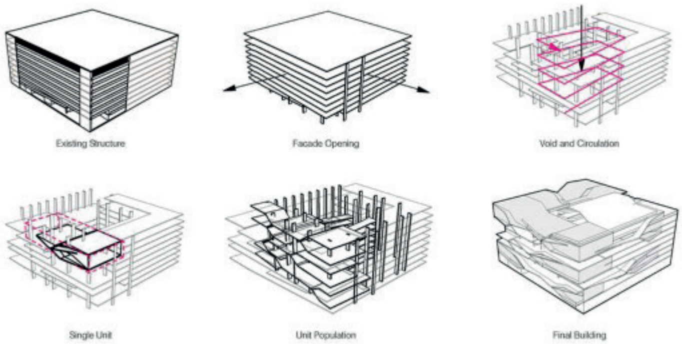


FIGURE 1:

UNSTUDIO DIAGRAM; EACH PHASE HIGHLIGHTS AN INDIVIDUAL DESIGN DECISION, LIMITING WHAT IS DEPICTED IN EACH STEP. SOURCE: UNSTUDIO

Some expressive sketches catch an architectural essence with minimal means – they serve as a point of reference for reasoning and further development during subsequent design steps. They combine a minimum of semantic content with a maximum of artistic expression.

The drawing process is not just a matter of imitation, of denoting a mental image that is by and large finished, but it is a precise response to a precise absence. This "precise absence" forces designers to respond in ways that are clearly matched and oriented towards the subject matter.

Nevertheless, the lines, shapes and planes of architectural drawings have an abstracting quality much like musical scores.

This abstracting quality allows one to understand the architectural object as being imbued with a certain agency. That is, the capacity to actively guide and direct thinking processes. There is a certain holistic quality to early process sketches that is only accessible, it seems, through their partial, open presence: in such sketches, many qualities of architectural objects are hinted at or suggested, but not spelled out. Yet, they are strangely enough vividly present, drawing the observer into the drawing, encouraging him to form associations in his mind. Again, the concept of iterability surfaces here, although not in a linguistic form. It is as if drawings encourage a mental, generative iterability with regards to their contents. In an accurate analysis by Emma Cocker, this iterability is regarded as a critical and creative faculty:

> *(...) the hypothesis emerges as autonomous critical activity, no longer bound by the repetitious cycles of testing and validation to which is it subjected in other fields. Its mere conjecture is rescued from the pejorative, recast as the pleasurable reverie of the thinking mind engaged in nascent speculation. Released from the stranglehold of teleological knowledge production, it is possible to discern specific properties or characteristics within the hypothesis that, in turn, point to certain critical operations at play within the practice of drawing.*[122]

This analysis describes exactly what happens in drawing. In combining indicative and expressive signs fluently in a single process of exploration – Cocker accurately uses the term "conjecture" – the act of notation reveals its potential as a thinking tool. Seamlessly combining free expression with precise indications, drawing allows one to create an imaginary world with great precision and expressive power alike. Moreover, the hypothesis, when applied continuously and dynamically is not just a response to a question but is a mode of exploration. Not unlike Kant's reflecting judgement, the hypothesis in drawing assumes the status of an autonomous, spontaneous and creative gesture of experimentation, divorced from the rigidity imposed by either validation or refutation.

Peter Zumthor regarded drawings as entities shot through with gaps in which the imagination can freely wander.[123] The essentially incomplete, allusive character of architectural notation actively encourages the mind to wander around in it, to inhabit the drawing in thought and to postulate hypotheses about the blanks.

Some sixty years earlier, Michael Polanyi already formulated a similar idea. He argued that the meaning of a representation or objects emerged once an author "dwells in" it, interiorizing its features and regarding it as a world on its own – a conceptual microcosm to be inhabited and explored.[124] It is through such indwelling that meaning gradually and experientially emerges: once the object is viewed from an "internal" viewpoint, certain features light up and become carriers of meaning, inspirations to be explored further, or irritations in need of solution.[125]

The absence of too many particulars focuses the spotlight of attention on what is present or present-in-absence, allowing drawings to develop a "vector of abstraction", or "sharp abstract point", as Bachelard called it.[126] The idea of a "sharp abstraction" is seemingly paradoxical, yet strangely effective in capturing precisely that evocative quality that makes drawings so attractive.

An abstract quality has nothing to do with being vague or undefined. Instead, it is abstraction that simultaneously embodies the core of an idea and its evocative characteristics. Even the first sketch is not an arbitrary jumble of loose elements: it points towards the essence of an idea in a purposively deployed visual idiom. Likewise, architectural diagrams possess a clarity that is a direct result of their abstract nature. They filter obfuscation out, depicting the bare minimum of an idea in a format that is simplified without being simple; understandable without being unrefined; yet open and inviting of reflection (fig. 2). Sharp abstraction is the means through which the essence of an idea can be grasped, however incompletely or obliquely. Yet, the first grasp is necessary to set off a process of directed inquiry.

Zumthor emphasizes the necessity of this incompleteness: the drawing or model has to contain blank spaces in which the imagination can enter. The blanks are the niches for something new to be created at all, be it through imagining what should be in the blank, or by considering the elements surrounding it.[127] In this context, the perception is *"Besitzernehmend"*, a term that has no English equivalent, but that can be translated as "taking-in-possession". We apply this possessive gesture to the act of inhabiting, of literally moving in. Hence the accurate observation that "each drawing is made from the inside out, leaving a trail for others to follow from the outside in."[128] The signs that make up the drawing draw the observer in, allowing him to wander around in it, to inhabit it, focusing on different aspects every time a tour is made. As such, the drawing allows one to become an "immersed spectator" – it is a virtual reality.[129]

To a degree, the signs of which drawings are made up are not just fixed, rigid inscriptions that can be read in different ways, but are themselves unchangeable. They can be interpreted through a process of endless iteration and re-performance, just as the diagrams of UNStudio allow for endless re-combination and the emergence of new ideas. However, they are themselves also flexible, or "plastic" in Malabou's sense, allowing them to be shaped and reshaped by the context in which they are applied, but nevertheless retaining an immediate expressiveness.[130]

Indeed, they *must* be expressive – if the lines, points, planes, symbols and coordinates must give rise to something new, if they are to open up "spaces of alterity" in which different possibilities can be thought by means of repeating the same representational gesture. As we discussed, the signs that constitute drawings are indeed mixed: they are indicative and expressive; precise and evocative; present yet open; and sometimes present in their very absence, at which point often a new sketch or iteration starts. If "repetition" is a matter of making similar, yet not identical drawings, then "novelty" is produced by the space that coalesces into being between signs and their interplay.

4) Notation in the Space of Formalization

In both its manual and digital forms, drawing shares many characteristics with writing, especially in its reliance on producing inscriptions or traces. Particularly relevant here is De Certeau's conception of notational practices.[131] According to him, such notation takes place in a blank space *(un espace propre)* that forms an island, isolated from the outside world as long as it is used for notational practices. The notational character of this space has tangible effects on the outside world: what is written or drawn on this plane affects how the outside world is perceived (fig. 3). This conception of drawing as taking place within a defined space is fully applicable to manual and digital drawing. The virtual space and the paper can be understood as clearly marked domains in which experimentation takes place.

Admittedly, there are differences in terms of materiality: drawing on a paper with ink is clearly a different experience than drawing in the phenomenally reductive space of digital production. The act of drawing (or notating) is an act of explorative yet expressive reasoning and extrapolation. What emerges in the blank space is viewed as a virtual world to be inhabited or as a representational scheme.

The space for drawing is a space of formalization, a plane where (visual) language and conception are systematized. "The scriptural enterprise transforms or retains within itself what it receives from the outside and creates internally the instruments for the appropriation of the external space".[132] Indeed, drawing is a form of appropriating the world, of manipulating its materials and creating in that manner the instruments to change the world outside the drawing space.

What notational practices create, therefore, are not just outcomes or solutions, but effective tools and mechanisms for better thinking and designing – "the nascent speculation" necessary to propose requisite changes and alterations. If we apply this thought to architectural design, drawing (both digital and manual) is done to develop the properties and qualities of an absent, architectural object – and simultaneously the means to think and represent it. Thus, architectural drawing creates both the preconditions

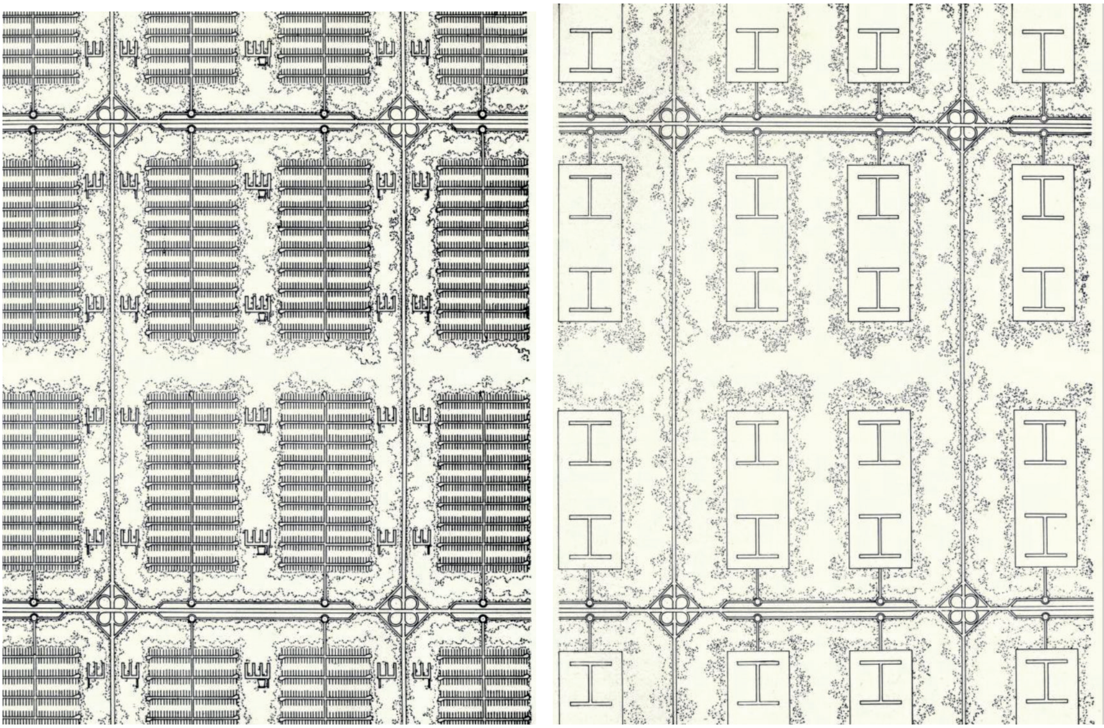


FIGURE 2:

ABSTRACTION IN THE REPRESENTATION OF A PLANNED SETTLEMENT. SOME ELEMENTS (FOR INSTANCE THE TRAFFIC JUNCTIONS) ARE WORKED OUT IN DETAIL, WHILE OTHERS (FOR INSTANCE, PUBLIC SPACE DETAILS) ARE LEFT OPEN. SOURCE: HILBERSEIMER 1944 for representing and realizing its built results. In both instances, thoughts become matter, either in the form of a representation or in the form of a built object, with the notational act of drawing functioning as a bridge between the mental and the material.[133]

The act of formalization is an important feature of drawing, and possibly one that caused Goodman to regard architecture as "mixed and transitional". Through formalization, the images that are being produced enter a visual format, the characteristics of which we discussed.

Put differently – in Krämer's terms – images in the broad sense possess a degree of "operative visuality" *(operative Bildlichkeit)*. The theme that Krämer touches upon is what the exact role of images in our contemporary visual culture is – especially when it comes to generating knowledge. Images are not just supporting entities that serve to facilitate the process of putting everything that is thought in discursive terms. Their existence as visual entities is not reducible to a communicative or linguistic role, although they contain indicative and expressive signs. Instead, Krämer raises the question whether knowledge generation should not move from a "grammatology" focused on linguistic structures to a "diagrammatology" focused on the visual potentials of images in conjunction with text.[134] To relate it back to the central question of this essay: can we move beyond Goodman with the aid of the theory discussed this far?

Krämer identifies a few features of operative visuality that overlaps with the account of De Certeau, notably its panoramic character. The eye can receive multiple images at the same time. It can catch the essence of an object literally in a split second, given enough clues and partial representations. The fact that drawings are two-dimensional (even 3D drawings on a screen) allows one to read a drawing, and to give it an orientation. Some of its features are in the foreground; others in the background. Some features occupy the centre; others are peripheral. Still, there is a certain ordering to its elements, an implicit and initially barely perceptible ordering that defies easy cognitive access.

Goodman's concept of notationality shares with it the emphasis on reading and the ordered appearance of notation. As drawings are meant to be read and interpreted, their potential rests in the fact that in them something singular can be seen as something general. A perspective drawing of a certain building in its context may cause one "to think of a similar one", or it may set off a chain of associations. There is a close link to an effect that Schön described as "see-as".[135] As worked out elsewhere, designers use drawing not just as a kind of "serial problem solving" aid but simultaneously as a medium in which recognition and rethinking play a constitutive role through graphic inscriptions.[136]

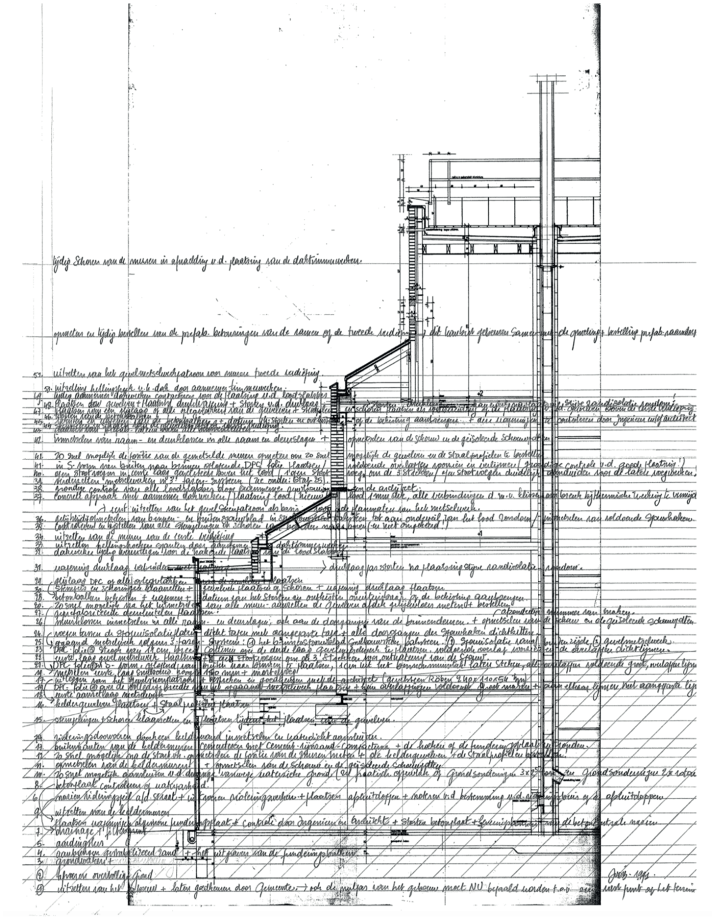


FIGURE 3:

A CHRONOLOGICAL DRAWING FROM VAN DEN BERGHE (2013), *THE VDV-C HOUSE* (1990), AN ANNOTATION OF A VERTICAL SECTION - OR, A FORMALIZATION OF EACH STEP. THE DRAWING OVERLAYS DIFFERENT PROCESSES THAT WILL TAKE PLACE IN TIME, RENDERING THEM EXPLICIT IN A GESTURE OF FORMALIZATION.

The semantic richness of artefacts enables designers to inhabit or "dwell inside" the objects they create and make present. This immersive exercise takes place in a space of formalization, allowing the designer to imbue creative and allusive ideas with a sense of discursivity, rationality and rigorousness.

As method of exploration, drawing becomes a mode of inquiry, a process of grasping disparate elements of an idea, or of developing certain aspects of it. The notationality at work in architectural design processes is generative in its creative, spontaneous and critical potential.

As such, the drawing is not just a stepping-stone in a continuous and more or less linear solving process, but a dynamic and non-linear combination of acting, evoking, and observing. On this account, Krämer notes that the line as mark is the archetypical act of defining – the drawing act as such. The distinction or the line marks an asymmetry: an object is inside or outside the boundary; it is defined by its edges or it is open; it contrasts with its environment or disappears in it. Precisely in this characteristic of the graphic language, Krämer asserts, consists its epistemic potential. Generation of options and possibilities, thinking about the operational constraints and visualizing these options are inextricably intertwined, and mutually necessary to arrive at coherent design proposals at all.[137]

5) Generative Notationality

Summarizing the points discussed above, we postulate the following: architectural drawing is an explicitly notational practice that is nevertheless not reducible to Goodman's concept of notationality, although it is similar in some respects. Yet, it is inextricably bound to the act of inscribing, of notating, although the inscription itself plays a very different role than in Goodman's theory. The signs that are inscribed are themselves open-ended and subject to change. They can be interpreted in different ways, opening up the new possibilities, taking on different roles in different contexts. Therefore, the act of repetitive representation in the context of a directed design process creates a series of objects composed of different layers of meaning.

This richness of meaning allows designers to inhabit or "dwell inside" the objects they create and make present. Yet, this immersive exercise takes place in a space of formalization, allowing the designer to imbue creative and allusive ideas with a sense of discursivity, rationality and rigorousness.[138] The formalization is a double one: the drawing is a material trace of the thought, giving it a fixed point in the physical world, and it simultaneously imbues the drawn object with tangible properties like size, material or shape. With drawing, the idea moves from the mental to the discursive – from something that is grasped by the mind to something that can be grasped in natural language.

Taking the points raised above into account, we conjecture that the rigidity of Goodman's account stems from the fact that architectural images are to a degree pictorial: they can depict the object that is being designed life-like in its full expressiveness. Yet, such representations are not necessarily to be read as only denoting such an object in the same way that a painting resembles an existing building. Unlike a work of art, the value of architectural notation resides primarily in its abstractive-yet-expressive quality, the so-called "sharp abstraction". In that respect, architectural images often resemble maps rather than blueprints, as argued by Miller:

> *By depicting certain properties as highly isomorphic while other details are omitted or stylized, map designers affirm the importance of certain kinds of information and relationships while downplaying other details. It is vital to the success of a map that it be isomorphic in the properties most vital to a map's intended usage.*[139]

Like every effective representation, the tension between what is depicted and what is omitted determines the room for interpretation. Architectural representations are indeed shot through with perceptual and representational gaps and holes that can be inhabited through the imagination. Yet, the notational character of sections, plans, perspectives and elevations stems from the fact that there is a tangible and productive tension between what is determined by unambiguous symbols and more evocative, allusive elements of drawings.

On one hand, Goodman's idea that symbols allow for the reproduction of a work is to some degree true. On the other hand, architectural drawings are not therefore reducible to only such elements.

So, architectural design can be seen as continuous, critical performance that utilizes notation, but is not reducible to it. The resulting drawings, models, animations – and eventually buildings and spaces – that emerge from this process are not reducible to an idealized type/token distinction as they elude the idea of narrow teleological knowledge production under predefined categories.

Goodman's application of the type/token distinction to architecture does not perform the explanatory work for which it was invented, because the process that is at work in architectural design is not reducible to this distinction at all.

First, because the fact that drawings are not composed of notations in a narrow linguistic manner.

Second, because the process of architectural drawing does not run straightforwardly from undefined to defined, or from abstract to concrete, or from conceptual to practical. The absences and blanks in the drawing serve as spaces for exploration and creative performance. Moreover, the fact that the act of drawing occurs in a space of formalization in which signs are made frees it from mere production of knowledge. Instead, drawing becomes a mode of inquiry, a process of grasping disparate elements of an idea, or of developing certain aspects of it.

The notationality of architectural design processes is generative in its creative, spontaneous and critical potential. It is a necessary condition for architectural thinking as such, as it is the (pre)cognitive process that cannot be imagined apart from the artefacts it produces and acts of notation it engenders. The differential notations in an architectural design process jointly form a rich system of allusive, metaphorical and technical information that possesses a fully coherent "operative visuality". This body of information is too rich to be grasped completely at a glance. Therefore, to come to terms with it, repetition and layered evaluation, a careful approach that pays attention to those aspects individually and in conjunction with one another are necessary. The relative ambiguity of some of the artefacts produced in this process allows the productive imagination to play a key role through notational practices.

With the emergence of generative design methods, the question of notationality takes on renewed urgency. Not all architectural drawings are hand sketches in which there is a direct link between "acting, evoking, and observing". Instead, in many cases the architectural gesture is no longer one of notation in the strict sense.

Yet, the new, digital architectural gestures seem to affect the mind differently than hand drawing does – and having made this observation, we might well conclude that the broader concept of Goodman's notationality as developed here may require still further revisions in the future, if only to better understand the emerging relations between notation, generation and visualization in the age of mixed manual and digital drawing.

The Simulative Stance

Epistemic Enactment in Architectural Design

1) Introduction

Architectural design practices possess epistemic (knowledge-generating) value.[140] However, this observation introduces questions about how this knowledge generation works. In particular, how can judgements and assertions with epistemic value be extracted from the artefacts that take shape during design processes? How is it possible to acquire knowledge from them?

We examine the idea that such knowledge acquisition is enabled by actively enacting different perspectives on a given design proposal. We call this "epistemic enactment". These forms of enactment are in turn enabled by an attitudinal disposition that we call the "simulative stance". By adopting the simulative stance, various forms of epistemic enactment become possible. In other words, it takes the appropriate mindset to epistemically enact the design proposal from different angles or roles. This enactment is mediated by the production of architectural artefacts (fig. 1). Models allow for detailed insight into the spatial properties of a design proposal and may be looked at from ground level or a bird's-eye view. Likewise, drawings like sections or elevations enable one to "experience" the perspective from someone inhabiting the depicted space.

Of course, this interpretation of architectural design processes commits us to certain presuppositions. Notably, we commit to two ideas:

a) that knowledge is produced by essentially embodied beings, and that generating knowledge is a dual cognitive-affective process in which the body is intimately and irreducibly involved.

b) because of (a) we maintain that enactive roles are played out through design processes, avoiding the assumption that knowledge production is a process that takes only place in the brain. However, we will – for reasons of convenience – assume rather than defend this theoretical position as there is a voluminous literature available on this topic.

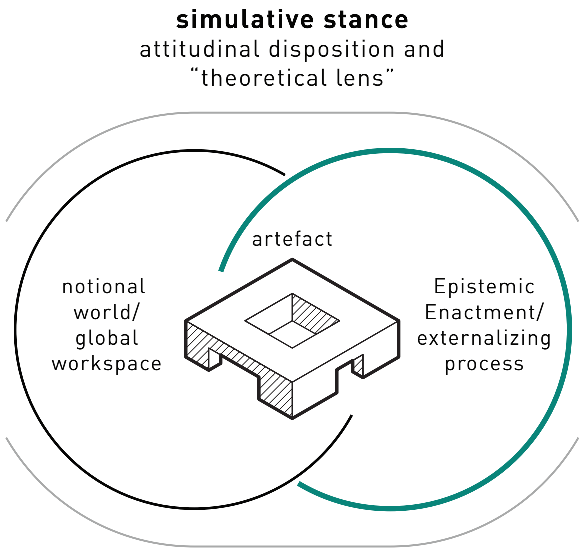


FIGURE 1:

THE RELATIONS BETWEEN THE SIMULATIVE STANCE, EPISTEMIC ENACTMENT AND THE PRODUCTION OF PROCESS ARTEFACTS.

Following from (a) and (b), we emphasize that architectural design (indeed, any form of designing at all) is not merely a rational, deliberative process, although deliberation and conceptual thought are part and parcel of it.

Instead, we maintain that designing is a thoroughly embodied process, in which the body and all its physical possibilities is actively engaged. Those who learned to draw on the classical drafting table still know how “zooming in” meant bending over a drawing, and coming close to the paper, while “zooming out” involved taking a few steps back and taking the whole scene into account. In both cases, physical distance was enacted through the body, and every line on the drawing was traced out. Lower back pain, cramped fingers and stiff shoulders were part of the design process, because the body was so intensely used.

Distancing and zooming in were activities in which not only ratiocination, but the entire proprioceptive system was involved. The same point can be raised with regard to affect and emotions. Designing is an intensely emotional and affective activity, in which episodes of boredom, frustration, but equally breakthrough and inspiration follow one another. So, the thought that design is to some degree enactive follows naturally from this commitment. Likewise, when we discuss knowledge, we mean with this term not just inductively, deductively or inferentially constructed assertions or statements, nor a mere factual grasp of some content matter. Instead, we mean with “knowledge” the full spectrum of human experiential capacity, as it is enabled by bodily systems including but not constrained to cognitive capacities.

2) The Simulative Stance and Epistemic Enactment

To analyse architectural objects as carriers of knowledge, one commits to the assertion that buildings (and we may extend this to “the built environment”) are registers of different types of knowledge.[141] If we analyse the ways in which these types of knowledge permeate process artefacts (like sketches, 3D models, models, drawings etc.), we see how knowledge becomes embedded in the built environment.

In everyday life, human beings find themselves confronted with a variety of artefacts and objects. They range from barometers to xylophones, from escalators to chainsaws and light switches. Our spontaneous grasp on how they function often eludes us until the time they cease functioning. A new computer program that must be mastered confronts one with assumptions and shortcomings in one’s cognition or an insufficient grasp of fundamental skills. What requires explanation is how our skill for handling objects with limited understanding and insufficient knowledge functions.

The American philosopher Daniel Dennett proposed that the answer lies in our attitude towards objects. As beneficiaries of the “Machine Age”, we assume that anything mechanical (and digital) will function in certain predictable ways. Buttons are made for pressing, levers for pulling, signs for reading, and screens for providing readable information or touching. The idea of a computer providing feedback on our actions makes only sense if we see it as a machine that functions according to a certain intelligible logic and largely fixed procedural structure. Dennett calls this attitude towards machines the "design stance". By adopting the design stance, one assumes that a given machine has been purposively designed and that it can be used to fulfil its intended goal.[142] Moreover, it includes the assumption that we as users can interpret and meaningfully utilize the feedback that the machine provides.

If we take this thought one step further, we see that we apply approximately the same reasoning to human beings: we consider them autonomous agents with a degree of rationality and some overlap with our own psychological dispositions. We do not regard them as mere automata. Instead, everyday intersubjective interaction is guided by what Dennett calls the "intentional stance". This is the attitude adopted towards beings that have content-filled mental states and an actual inner life. We ascribe motives and reasons to other human beings to interpret and respond to their behaviour. Likewise, we use such mental simulations to predict behaviour and formulate fitting responses or appropriate courses of action.

The design stance and intentional stance are both attitudinal dispositions: that is, they are based on bodies of implicitly accepted assumptions that direct and determine the way the world or its discrete characteristics are perceived and interpreted. An attitudinal disposition forms the lens through which the world is viewed, determining which features trigger us, and which "light up" in perception.[143] Not coincidentally, there is a close analogy between such dispositions and the idea of a "design lens", that is, the manner in which a given problem or issue is framed and approached.[144]

What does this excursus have to do with designing? As architects, urban planners and landscape architects, we design physical environments that combine functional needs, constructive requirements, and infrastructural connections with affects, atmospheres, aesthetics and emotive qualities (often under the rubric of "atmosphere"). These environments significantly determine the quality of life for other human beings. In short, designers must regard the environment as a functional configuration that is jointly operated by numerous human beings.

Therefore, it has to make sense to a kind of rational, autonomous agent that is in certain aspects similar to the designer himself. So, designers share a cognitive, psychological and physical constitution with the target group for whom they design. Historically, this similarity has played an instrumental role in architecture and urban planning: from the "Vitruvian man" to the “average family” or “average individual”. Both architecture and city planning postulate assumptions about such generic and thus fictional characters, using them as points of reference during designing. On one hand, fictional characters enable one to make decisions on their behalf by departing from relatively safe assumptions.

On the other hand, the marked disadvantage of this strategy is that fictional characters are often blatant simplifications or even caricatures of the entities they are supposed to represent. The “average family” has often not much in common with a randomly selected real family.

In designing the built environment, designers combine the design stance and the intentional stance into a compound attitudinal disposition focused on the future needs of target groups that are not intimately known. Nevertheless, designers share a cognitive constitution and a physical living environment with them. This compound attitudinal disposition is what we call the “simulative stance”.

Designers consciously and unconsciously adopt the simulative stance while creating and interpreting architectural artefacts. It informs their ways of looking at drawings, models, animations, sketches and other process artefacts. It focuses their interest in analysing how other humans use the environment, how technical details are constructed, and how materiality influences aesthetic appearance. In this sense, the designer internalizes and embodies his expertise: he is attuned to the sensitivities of drawings, models or sketches in the same way that a conductor is to the performance of an orchestra. Small, almost imperceptible changes or features acquire meaning when looked at through expert eyes. The simulative stance with which the designer views the world frames his perception, and consequently it determines the meanings he attaches to the properties of the drawing through a process of intellectualization.[145]

At this point, we may deal with a first objection. If the simulative stance is an enabling condition for knowledge accumulation, is this not an oversimplification? Is the simulative stance not again some mysterious property X or capacity Y that eludes explanation? Or is it just a different name for what was in former times termed intuition or creativity? We believe not, and therefore we maintain that the simulative stance functions through a fully intelligible process called epistemic enactment, practised during the production and interpretation of architectural artefacts. In epistemic enactment, designers deliberately and voluntarily adopt a certain perspective towards an idea.

The perspective acts as a helpful tool to act “as-if”.[146] Temporarily, the designer regards the idea from the assumed position he occupies, acting “as if” he experiences certain features from his point of view. This speculation-driven and perspectivist mode of thinking generates a series of conjectures and inferences that appear relevant from the adopted perspective.

A deliberately adopted perspective affords the simplification to "perceive" and "enact" the features of a given idea more clearly. The deliberate abstraction or simplification offered by the perspective unlocks new epistemological domains. One must view a process artefact from an assumed point to extract, perceive or notice properties that are only perceptible from that very point of view. The assumed perspective brings some features into focus, while omitting or blurring others. And that is exactly is power. A perspective cuts the noise out, while allowing certain features or perceptible patterns to come to the fore.

Summarizing, epistemic enactment is a form of active, embodied enactment that consists in the designer switching between multiple roles during the design process.[147] Two of these roles will be discussed in the next section.[148]

3) Anthropological and Symbolic Languages

The first role a designer adopts is that of a "creator" in a narrow sense of the term. This does not mean that the designer is reducible to a kind of utterly rational, idealized problem solver or *homo economicus*. To think so was a foundational assumption that guided the first generation of design theorists in their conceptualization of design processes.[149] However, if one understands the designer as an expert in utilizing different types of knowledge, and as endowed with analytic capacities related to relevant frames of reference, and as a subject capable of purposive perspective-taking, it becomes plausible that his skill-set allows him to adopt a temporary, external, quasi-distanced perspective towards the ideas he creates. In this role he is acting according to a level of knowledge that is kaleidoscopic yet sufficient, working with artefacts that are not yet completely empirical objects, but that are not completely unintelligible either.[150] Designers do not have perfect knowledge of all aspects of their output, but they have sufficient knowledge to produce generally reliable statements or relatively safe assumptions about their artefacts. This broad knowledge base enables them to gradually develop architectural ideas that possess a tangible internal coherency and intelligibility.

The second role the designer adopts is that of "immersed spectator", interpreting and analysing artefacts from an internal viewpoint, for instance as a participating user. This role utilizes the capacity of perspective-taking in a different manner. Instead of being an external expert providing professional verdicts or judgements, the designer temporarily adopts the mental attitude and perspective of a given user. He analyses the proposal from a deliberately simplified, first-person viewpoint. The analysis becomes an immersed and subject-oriented reflection that only holds true for certain aspects of the

Designers internalize and embody their expertise: they are attuned to the sensitivities of drawings, models or sketches in the same way that a conductor is to the performance of an orchestra. Small, almost imperceptible changes or features acquire a highly specific meaning when looked at through expert eyes.

Immersive observation utilizes the capacity of perspective-taking in a different manner. Instead of providing professional verdicts or judgements, designers temporarily adopt the mental attitude and perspective of a given user. They analyze their proposals from a deliberately simplified, first-person viewpoint.

design proposal.[151] By combining an array of such different viewpoints, the designer can make qualitative assertions on behalf of imaginary users such as the “typical pedestrian” or “typical vehicle driver”.

During this switching of roles, the designer never stops being a designer, even in the most immersed, subjective moments. There is always an element of the creator looking over the shoulder of the immersed spectator. How does the designer adopt these roles with regards to his ideas and concepts? The answer lies in the process of architectural representation, focusing the inquiry around a wide variety of process artefacts (such as models, sketches, 3D models, CAD drawings etc.) in designing. Series of process artefacts jointly create necessary and sufficient conditions for architectural thinking.[152]

Architectural artefacts are structural registers of different types of knowledge, associative chains, atmospheric moods and superimposed insights. However, they are not reducible to either one of the components just mentioned. Two superimposed worlds collide and overlap during designing: the real, physical world with all its challenges, limitations and problems, and the idealized world of concepts and ideas:

> *Through design thinking, [the designer] makes a projection, literally a fore-image of what does not exist, and explicates the possibilities and requirements to realize this futurity. (For example the building plans for a house of the masterplan for a site).*[153]

Such fore-images are incomplete during their conception; they do not represent fully-formed future worlds. Nevertheless, such images are inextricably oriented towards the future and how it should be.[154] Indeed, Horst Rittel termed in once a *“Sollbild”* – a “should-image” that shows what the world should become. Or, put differently, the envisioning of the “ideal” in the confines of the “real”.[155] The act of projection implies a projection, an overlay of the imaginary on the real. These worlds can be conceived as possible, probable and desired.[156] Some worlds may be desirable, but impossible; other worlds may be possible but undesirable; yet others are possible but not probable. Designing them is a necessary condition to conceive them in their entirety and to gain insight in what they require or offer. These requirements are “bestaansvoorwaarden” (necessary conditions for existing).[157] They are not only required for realizing a design, but the process of gradual representation is itself a necessary condition for an architectural idea to develop at all. De Jong rightly focuses on the unity or totality of designed worlds or ideas. It is because of their totality and comprehensiveness that they become instruments of knowledge, as formulated in different terms by Jacques Derrida:

> *But within structure there is not only form, relation, and configuration. There is also interdependency and a totality which is always concrete. [...]*

> *Henceforth, the totality is more clearly perceived, the panorama and the panoramagram are possible.*[158]

What Derrida says here is about writing but is just as valid for architectural design. The structuring quality of design determines relations, dependencies and configurations, with artefacts serving as panoramic entities. They are panoramic in the sense that a careful juxtaposition and combination of their elements and codified knowledge allows one to see beyond their individual components in a synoptic, generalist manner. Conversely, the same panoramic quality enables one to perceive their potentials and possibilities in relation to one another. To focus on a detail is for a designer often not a way of nitpicking or being overtly perfectionist. Instead, it is the detail in relation to the whole that counts – or the whole in relation to the detail. In utilizing the panoramic view that zooms in and out in the interest of creating an internally consistent outcome, relational thinking is essential.

Moreover, some artefacts are panoramic in the sense that drawing or inscribing takes literally place on a – sometimes virtual – surface on which elements, ideas and partial ideas are interwoven into larger, composite representations. The panoramic surface allows one to see in one glance the (possible) connections that unite different parts of an idea. To aid this perceptual process, architectural representation employs deliberately schematic means:

> *Thanks to a more or less openly acknowledged schematization and spatialization, one can glance over the field divested of its forces more freely or diagrammatically. Or one can glance over the totality divested of its forces, even if it is the totality of form and meaning, for what is in question, in this case, is meaning rethought as form; and structure is the formal unity of form and meaning.*[159]

Derrida's argumentation in this passage is again fully applicable to architectural design: its operations of schematization and abstraction allow designers to freely explore and compare different configurations and options, each of which is subject to different forces shaping it. Through cycles of representation and evaluation, different options are expressed as architectural forms, in turn acquiring meaning for the designer as creator and/or immersed spectator.[160]

Observing the ideal world of schematization and spatialization as overlapping and intersecting on the real world sets off new sequences of ideas and thoughts. Such associative sequences enable designers to adopt different interpretive perspectives during designing.[161] The contrast between what is visualized and what is really existent provides the creative impetus to consider different solution types, concepts, viewpoints and spatial arrangements – often overlapping or side by side in varying constellations.

Of course, this assertion assumes that representing is a form of enacting. Or alternatively, it equates the activity of representing with enacting – and subsequently thinking or deciding in a design process. How enacting and representing are interwoven becomes apparent in a distinction drawn by De Certeau. He describes how inhabitants of a residential building may use different descriptions to describe their surrounding by providing a map or a tour.[162] A map is a description of the type "the storage room is left from the corridor", while a tour is a description of the type "enter the room, turn right, and pass the fireplace". The distinction between these descriptions can be drawn at many levels. The map is operational and juxtaposing: it posits and relates entities with regards to one another on one unified plane (the living room is left of...), while the tour is instructive; it describes sequences of actions that are chronologically ordered (turn right, then walk on...).

During designing these two modes of description exist side by side. Representations are used to generate descriptions that switch between perspectives (external and immersed) and levels of generality. A plan of a neighbourhood may give rise to map-like descriptions of the type "the residential development is planned next to the park", or "the parking lot is centrally located". Conversely, perspective visualizations may give rise to tour-like descriptions: "if you move along this route, this landmark building is continuously visible". Inferences and conclusions of this type directly shape the design process. De Certeau traces the relation between perceiving and acting back to narrative acts: the tour organizes discursive operations, while the map totalizes observations. Put differently, these two poles of experience utilize two languages: an anthropological language of felt and lived experience combined with a symbolic language of formal, abstract codification.[163]

Epistemic enactment commences through representing the "imagined world" from different vantage points in anthropological and symbolic languages (fig. 2). The designer in his Janus-faced role as creator and immersed spectator speaks two languages simultaneously. One is symbolic, allowing for abstract, formal representation; the other is anthropological and immersive, allowing for first-person representation.[164] And if we think back to Derrida's statement that "meaning is rethought as form", we can understand how anthropological language seamlessly blends into symbolic language and *vice versa*.

Summarizing the argument: designers practice epistemic enactment by switching between roles. We discussed the roles of creator and immersed spectator. This attitudinal switching is exercised through deliberate representation and evaluation in an integrated developmental process. Epistemic enactment is enabled by the simulative stance. Using this attitudinal disposition, the designer utilizes two different languages simultaneously: a formal, symbolic language that allows for

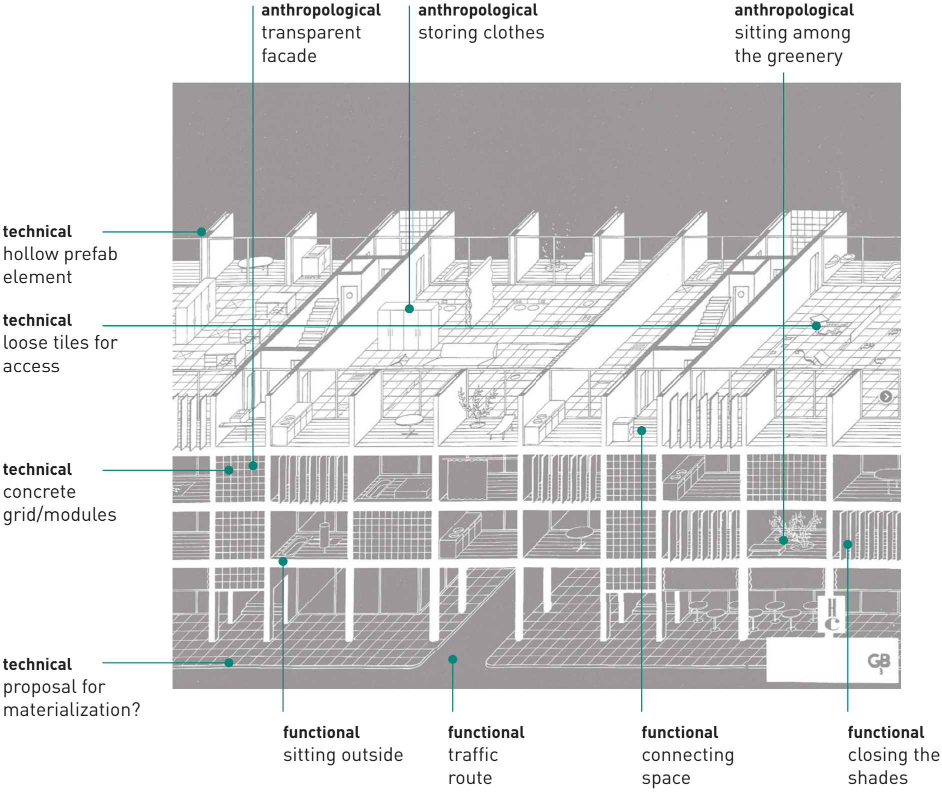


FIGURE 2:

ANALYSIS OF DIFFERENT ELEMENTS IN A DRAWING FROM THE 1990 ENTRY FOR THE HOUSING AND CITY COMPETITION BY NEUTELINGS, WALL, DE GEYTER AND ROODBEEN (ORIGINAL IMAGE VIA SOCKS-STUDIO: HTTP://SOCKS-STUDIO.COM/CATEGORY/VISUAL-ATLAS/ARCHITECTURE/).

abstracting content, and an anthropological language that allows for adopting an immersed perspective. Consequently, artefacts straddle symbolic and anthropological domains of expression. As designers dynamically switch perspectives, they narrate and specify the architectural object on multiple levels, using these different means of expression.

4) Comprehending Architectural Artefacts

Still, a further objection can be made in response to the core thesis of this essay. Namely, how can designers comprehend the representations they make as architectural totalities, given the fact that they are not completely reducible to any of their individual components? Does epistemic enactment not merely provide designers with a series of snapshots, loose fragments, and partial perspectives of their ideas instead of a coherent view to which epistemic value can be assigned?

The different modes of embodiment in a design process make artefacts semantically saturated environments: they simultaneously contain and generate multiple meanings, stories, relations, and narratives. Each redrawing, remodelling or re-interpreting embeds and derives knowledge from artefacts by means of successive representation. It follows that designers must possess a skill, disposition, or method to encode and decode information from artefacts. Jointly viewed, a series of artefacts provides the designer with a panoramic view on the whole and its parts. Together, they constitute a generative plane of representations: what is derived from and read into artefacts is more than what was put into it.

By lining up associations and ideas in a focused, quick-retrieval system, designers can quickly extract what is needed.[165] Recent work in neuroscience by Dehaene sheds light on how the brain selects disparate types of information for retrieval and direct use by pulling it in a kind of global, mental workspace, the mental equivalent of a designer's atelier.

We possess a mental router, an evolved architecture for extracting relevant information and dispatching it. The psychologist Bernard Baars calls it a "global workspace": an internal system, detached from the outside world, that allows us to freely entertain our mental images and spread them across the mind's vast array of specialized processors.[166]

The global workspace idea explains the tacitly understood wisdom we started with: namely, that the incessant search for precedents, partial ideas, replicable solutions and styles of visualization are pulled into mental repository of ideas that directs architectural production (fig. 3).

Focusing on a particular theme activates the mind to create more and more associations from memory. This enriches the theme by delving into the

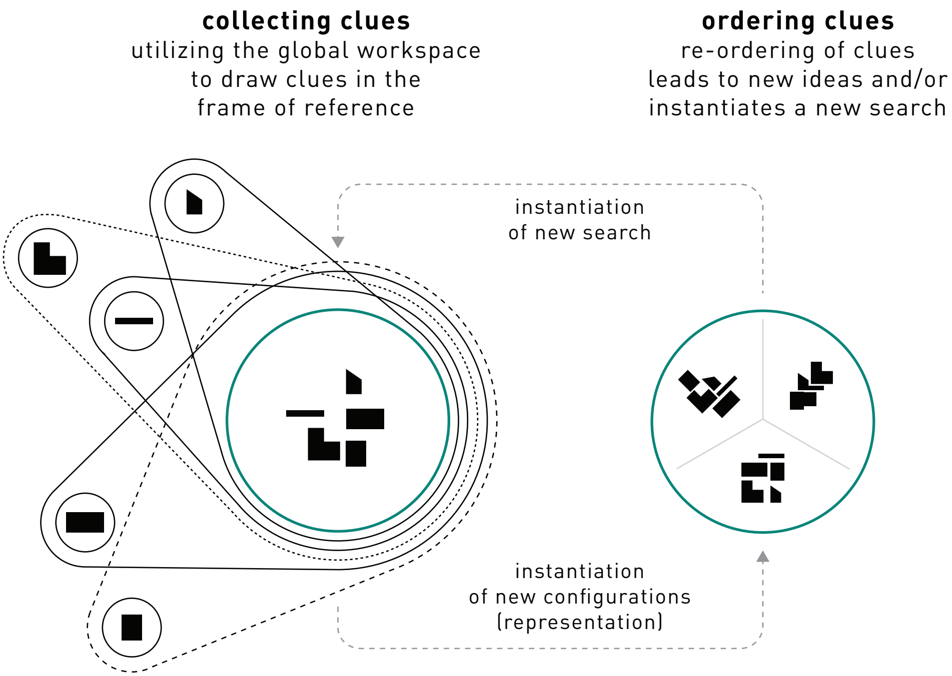


FIGURE 3:

PROCESS OF COLLECTING, ORDERING AND ASSEMBLING CLUES IN THE GLOBAL WORKSPACE, SETTING OFF NEW SEARCHES AND NEW POSSIBILITIES.

Focusing on a particular design theme activates the mind to create more and more associations around that given theme from memory. This gradually enriches the theme by delving into the mental archives, displaying the retrieved contents on the mental equivalent of a drawing table.

Representations point
beyond their immediate
content, and towards
architectural ideas that
can only be allusively
or obliquely be referred
to by juxtaposing
their symbolic and
anthropological contents
in a developing series
of integrative gestures

mental archives, displaying the retrieved contents on the mental equivalent of a drafting table. By selectively focusing on one detail or operation, the surrounding world is mentally blurred out and recedes into the background. This allows one to access the mental repository in a focused manner.[167] Precedents, partial ideas, replicable solutions and styles of visualization are compiled into a mental repository of clues and ideas that direct architectural production.[168]

Designers collect such clues into a "working frame" formed by the problem they address. This working frame becomes over time and by accumulation saturated with different types of content that are recombined and ordered in drawings, sketches and models. This rich content enables designers to understand the issues they work on from different perspectives.[169] Gadamer contends that "questioning opens up possibilities of meaning". In turn, the process of probing and questions dialogically develops and works out the meanings that can be embodied in an idea, detail or certain train of thought. By this process, what is meaningful "passes into one's own thinking on the subject".[170] The content in the working frame is fluid and changes it shape, causing an understanding of the problem that is not reducible to mere problem-solving by ratiocination.[171] If anything, it functions through immersion and generating possibilities, relations and alternatives.

Designers use their repository of core values and ideas in applying symbolic and anthropological languages to various contexts and issues while designing. The claim by architectural historian Alberto Pérez-Gómez that "architecture is the type of thought that makes good buildings possible" can be read against this background. To design is to adopt a type of thought, a certain associative and creative mental mindset that ceaselessly searches for the "new" and the "fitting". Representations point beyond their immediate content, and towards architectural ideas that can only be allusively be referred to by juxtaposing their symbolic and anthropological contents in a series of integrative gestures.[172]

The accumulation of process artefacts creates a semantically saturated environment of ideas, sketches, quick scribbles, notes, aesthetic details, half-finished models, concepts, technical specifications and diagrams. All these images and models jointly present an architectural idea or vision that can be understood at different levels – constructive, functional, technical or ecological.

However, the architectural design process does not just run linearly from indeterminate to determinate, or from undefined to defined. Instead, the artefacts contain different types of knowledge and always elude exhaustive description, leaving space for immersion, but simultaneously creating possibilities for deriving knowledge. This "surplus" is constitutive of its epistemic value. The incompleteness of an artefact is its greatest potential as generator of knowledge. Paradoxically, a degree of imprecision is needed to reach precision or definition at all:

> *[...] unbridled lucidity can destroy our understanding of complex matters. Scrutinize closely the particulars of a comprehensive entity and their meaning is effaced, our conception of the entity destroyed.*[173]

This assertion explains concisely why we can read architectural artefacts as comprehensive entities. Due to their semantic saturation, architectural artefacts are focal points and carriers of knowledge in a purposive, exploratory design process. They are focal points because they influence the type of epistemic enactment: a technical drawing may lead to technical considerations about how weather-resistant materials are, whether stairs are not too steep, whether the pavement will not become slippery during the winter, represented in a highly symbolic idiom. In turn, a large-scale urban plan may lead to considerations about travelling time, the scenography of a route or the distance to the nearest supermarket, represented from a more anthropological perspective. All these considerations are relevant although they are quite disparate.

The clues hauled into the working frame are rough materials to be ordered, connected, weighed, and scrutinized. Every representation is an attempt at ordering, at schematization and spatialization. The dimly perceived final design is the absent, yet driving core of these evaluations and perspective shifts. Put differently: representations of all the notions and fragments collectively point towards an idea that remains just out of focus, like a "de-centred centre" that structures all attempts at definition. Again, in Derrida's words: "By orienting and organizing the coherence of the system, the center of a structure permits the play of its elements inside the total form."[174]

And, we may add, even if the center of the enquiry (namely an architectural idea in development) is physically absent, it still generates the play of elements surrounding it. To put this play into effect and to utilize it, switching of perspectives, enacting and imagining are necessary strategies. The same can be said of utilizing various symbolic and anthropological languages. In an iterative series of representations, designers attempt to grasp, organize, orient and align ideas and different types of knowledge into coherent, meaningful wholes.

The representative process in architectural design affords different entry points for such an enacting performance by the designer. A quick street-level sketch reveals different aspects of an idea than a bird's-eye view rendering does. The relationships, interconnections, levels of generality, materiality etc. that are visible in one representation may be obscured in the other. All these elements are gradually pulled under the heading of one connective meaning or viewpoint through which a problem is addressed. The variety of conceptual and non-conceptual contents in artefacts necessitates a fluid switching between roles and considerations. For instance, technical information and cost calculations must be related to questions about everyday perception, aesthetics, materiality and usage by various target groups. To connect contents in such a fluid manner demands imaginative enactment of different roles and perspectives, both symbolic and anthropological.

Concluding, the totality of process artefacts and mental representations affords an extremely rich environment suffused with different types of knowledge that can claim a polyvalent epistemic value: namely, a developing, immersive and multi-faceted understanding of the design proposal on many different levels of precision.

Notes

Introduction

1) We borrow this term from Haarmann 2019.
2) Paans, O., Pasel, R., and Ehlen, B., Architectural Representation, the Controlled Future and Spatial Practice, in: Tofte, A., Rönn, M., and Wergeland, E. (eds.) *The Nordic Academic Press of Architectural Research (NAF/NAAR) Proceedings Series 2019-1: Reflecting Histories and Directing Futures*: 203–228.
3) Paans, O. and Pasel. R., Describing Liminal Knowledge in Architectural Design: Knowing What We Do Without Knowing Everything, in: *The International Journal of Design Education* 13.3 (2019): 13–25.
4) Paans, O. and Pasel, R., Drawing as Notational Thinking in Architectural Design, in: Storni, C., Leahy, K., McMahon, M., Lloyd, P., and Bohemia, E. (eds.) *Proceedings of DRS2018* vol. 4: 1474–1485.
5) Paans, O. and Pasel, R., The Simulative Stance: Architectural Design as Epistemic Enactment, in: Christensen, R., Drach, E., Gasperoni, L., Hallama, D., Hougaard, A., and Liptau, R. (eds.) *Artefakte des Entwerfens. Skizzieren, Zeichnen, Skripten, Modellieren*, (Berlin: Universitätsverlag der TU Berlin, 2020): 58–74.

1) Between Control and Reflection

6) Luce 2009: 28–29
7) Luce 2009: 30
8) Nowicki 2008: 284
9) A clear and early expression of this on empirical orientation can be found in Walter Gropius's 1929 text *The Sociological Foundations of the Minimum Dwelling*.
10) Asimow 1962: 20
11) Pérez-Gómez 2007: 12–13
12) Pérez-Gómez 2007: 13
13) Starkey 2007: 236
14) Paans and Pasel 2016
15) Rittel and Webber 1973; McCall and Burge 2016
16) Notably theorists of the "first generation" like Charles Eastman, Allen Newell, Horst Rittel, Werner Kunz, Melvin Webber, and Herbert Simon.
17) IEA, 2013: p. 57
18) IEA, 2013: p. 57
19) Tillie 2014: 19–21; Hajer and Dassen 2014: 37–38, 50–51
20) Gleiter 2014: 5

21) Gero and Kannengiesser 2008
22) Graves 1977: 384
23) Pérez-Gómez 2007: 13; Graves 1977: 393
24) van Fraassen 2008: 12–13
25) de Bruyn and Reuter 2011: 63
26) Turkle 2009: 81–82
27) Graves 1977: 392
28) Turkle 2009:83.
29) Nigianni 2007: 233
30) Nigianni 2007: 236
31) Foucault 2002: 49
32) Van Fraassen 2008: 29
33) Notably his *Critique of the Power of Judgment*, the work on which we mainly focus in this discussion.
34) de Bruyn and Reuter 2011: 85–86.
35) The activity of the (Kantian) imagination is by no means just conceptual. It requires the intermingling of non-conceptual and conceptual content.
36) Rawes 2007: 263
37) Paans 2020
38) Kant 2000: 235
39) Kant 2000: 236
40) Kant 2000: 237
41) Kant and Foucault would probably disagree about the "group of relations" in which objects are entangled. For Kant, these relations are largely centred around cognitive conditions. For Foucault, the relations are more social, disciplinary, and institutional. *The Archaeology of Knowledge* attempts to describe these relations.
42) In the *Critique of Pure Reason*, Kant does not give an unambiguous account of the imagination. In general—and without going in too much detail—it is safe to say that the imagination in the Kantian sense is a kind of dual capacity that is both integrative ("synthetic") and creative ("productive") in order to come to grips or to construct manifolds *(Mannigfaltige)* given in the sensual perception within time and space.
43) Krippendorff 2013: 227–228.
44) Darke 1978
45) Incidentally, Horst Rittel already made the general point that planning is a process of variety creation and reduction in his 1970 article *Der Planungsprozess als interativer Vorgang von Varietätserzeugung und Varietätseinschränkung* (*The Planning Process as Iterative Progression of Variety Generation and Variety Reduction*). However, he phrased this idea in rather process-oriented terms, excluding largely the idea of architectural qualities and multiple modelling spaces.
46) Lawson 2005: 76
47) Krautheim *et al.* 2014
48) Paans and Pasel 2014

49) An earlier version of his paper was originally published in: Paans, O., Pasel, R., and Ehlen, B., Architectural Representation, the Controlled Future and Spatial Practice, in: Tofte, A., Rönn, M., and Wergeland, E. (eds.) *The Nordic Academic Press of Architectural Research (NAF/NAAR) Proceedings Series 1: Reflecting Histories and Directing Futures* (2019): 203–228.

2) The Liminal Dimension

50) Friedman 2007
51) Polanyi 2009: 8
52) Ryle 2000
53) Mareis, 2011: 264–266; Müller and Thoring 2010
54) Hetherington 2011: 27
55) Alexander 1964: 48–50
56) Polanyi 2009: 7
57) Alexander 1964: 36
58) Müller and Thoring 2010
59) Nonaka and Takeuchi 1995
60) Friedman 2007
61) Ray 2009: 12
62) Collins 2006: 114–119
63) Niederrer 2007
64) Dorst and Cross 2003; Schön 1992
65) Brey *et al.* 2009: 41
66) Brey *et al.* 2009: 44
67) Jonas 2013
68) Tillie 2014
69) Hajer and Dassen 2014
70) De Bruyn and Reuter 2011
71) Schönwandt 2013
72) See Paans 2022: ch. 1
73) Knorr-Cetina 1999: 63
74) Land *et al.* 2014: 200
75) Knorr-Cetina 1999: 63–64
76) Knorr-Cetina 1999: 64
77) Knorr-Cetina 1999: 64
78) Knorr-Cetina 1999: 65
79) Goel 1992
80) Cross 2007; Lawson 2004; Pallasmaa 2015; Pirolli 1992
81) Goel 1992: 849

82) It is important to notice that the existence of such a discourse holds no explicit normative value. Some reasons given for the appearance of an idea might be downright faulty or bad. Like the Kantian aesthetic judgement, the assent is to universal understanding, not to universal approval or unanimity about the quality of the contents.
83) Pirolli 1992: 22–23
84) Polanyi 2005: 78; 387
85) Farias 2013
86) Stark and Girard 2002
87) Girard and Stark 2002: 1946
88) Farias 2013
89) Farias 2013: 91
90) Berger 2000; Fitch 2011; Van Den Berghe 2013: 667
91) Land *et al*. 2014: 206
92) Land *et al.* 2014: 206
93) Meyer and Land 2005
94) Goel and Pirolli 1992: 492
95) Ewenstein and Whyte, 2010: 76–77; See also Paans 2021, chapter 1 for an in-depth discussion of this theme.
96) Rheinberger 2008: 70–71
97) Polanyi 2005: 357
98) Paans 2020; Polanyi 2005 also calls inarticulate learning "interpretation". Although his idea bears some resemblance to hermeneutic interpretation as we encounter it in the work of Wilhelm Dilthey and Hans-Georg Gadamer, Polanyi's discussion focuses on the interplay of ideas rather than the historical development of conceptual understanding.
99) Goel 1992; Pirolli 1992
100) The expression "the space of reasons" was coined by the American philosopher Wilfrid Sellars. However, we use it here in a sense that significantly exceeds Sellars's original intention and treat it as containing both non-conceptual and conceptual contents.

3) Drawing as Notational Thinking

101) Edwards 2008: 12–13; Geer 2011: 45; Pallasmaa 2015: 92.
102) Schurk 2013: 538; Van Den Berghe 2013: 667
103) Goodman 1968
104) Krämer 2009
105) Goodman 1968: 127–156
106) Miller 2017
107) D'Cruz and Magnus 2014: 2–4
108) Goel 1991
109) Goodman 1968: 193
110) Graves 1977
111) Goodman 1968: 221

112) D'Cruz and Magnus 2014: 10–11
113) Derrida 1988: 7
114) Dernie 2013: 10
115) Edwards 2008: 12–13
116) Van Berkel & Bos 2006: 15
117) Derrida 1988: 7
118) Rheinberger 2008; Paans 2022, ch. 1
119) Parsons 2016: 16
120) Anderson 2016; Hilberseimer 1944; Ungers 1977
121) De Jong 1992: 10
122) Cocker 2017: 98
123) Zumthor 2014: 13
124) Polanyi 2009: 17–18
125) Wittgenstein already explores this thought in the *Philosophical Investigations.* However, while he uses examples from imagery, he never explicitly developed a "theory of drawing" over and above his remarks on language games.
126) Bachelard 2002: 26
127) Zumthor 2014: 13
128) Moore 2011: 35
129) Paans and Pasel 2020; See also ch. 3 in this volume.
130) Malabou 2009: 66–68
131) De Certeau 1988: 134–135
132) De Certeau 1988: 135
133) Van Den Berghe 2013: 667
134) Krämer 2009
135) Schön 1983; Wittgenstein 2009: 201–212; 219
136) Goldtschmidt 1992; Paans 2021
137) Krämer 2009
138) Zumthor 2014: 30–33
139) Miller 2017: 6

4) The Simulative Stance

140) Cross 1982: 222; Cross 2007; Geldof and Janssens 2007: 13 (author's translation); Lawson: 2004: 117–126; Girard and Stark: 2002: 1946; Hasenhütl 2009: 348–349; Whyte and Ewenstein 2010: 56; Paans 2019.
141) Bamford 2002: 252
142) Dennett 1989: 22–33.
143) Wittgenstein 2015: 193–214
144) Nelson and Stoltermann 2014: 67
145) See: Carpo 2011. The process of intellectualization partially covers the dynamics of the design process – in the sense that it describes how design acts make an architectural idea accessible to the intellect and to purposive reasoning. However, it should be kept in mind that this is

but one aspect of design processes. The design process as such is not reducible to intellectualization or ratiocination.

146) Buchanan (1992) defines this as a "placement", while Nelson and Stoltermann (2014) call it a "design lens" and Dorst (2015) calls it a "frame". Despite all terminological differences, all these concepts point towards the practice of "perspective-taking". An assignment is always addressed from within a subjective position.
147) For reasons of space, we discuss here only two roles that seem most obvious at first sight. However, it is obvious that a more elaborate taxonomy of roles could be defined. The authors do not maintain that the two roles discussed here are the only possible ones.
148) We only discuss two roles that seem prima facie most obvious. Arguably, a more elaborate taxonomy of roles could be defined.
149) For instance, design theorists like Herbert Simon, Allen Newell, Charles Eastman and Horst Rittel.
150) Knorr-Cetina 1999: 64–65.
151) See: Wirth 2015, chapter 4 for a series of discussions around the topic of "performance". Here is certainly a link to the performative aspects of design practice, although this essay cannot deal with this aspect in practice.
152) Pérez-Gómez 2007: 12–13
153) Geldof and Janssens 2007: 13
154) Reuter and Jonas 2013: 261–262
155) Nelson and Stoltermann 2014: 32–37
156) de Jong 1992: 9
157) de Jong 1992: 10
158) Derrida 2001: 3–4
159) Derrida 2001: 4
160) Somol and Whiting 2010: 188–203
161) Hasenhütl 2009: 348–349
162) de Certeau 1984: 118-120
163) de Certeau 1984: 119
164) Dennett 1989: 154–155
165) The neurological basis for this capacity is discussed in: Baars: 1996, 1997; Dehaene 2014.
166) Dehaene 2014: 163–165
167) Polanyi 2010: 18
168) Lawson 2004: 112
169) It should be noted that this semantic content is both symbolically and anthropologically embedded, as postulated by De Certeau (1984) A design proposal may be described according to its properties or materials in a technical idiom, but simultaneously as a place of social interactions or cultural significance.
170) Gadamer 2013: 383

171) See for a discussion on this focusing capacity: Ludwig Wittgenstein 2015: 210–212, 215–217, 219; See also: Vermaas *et al.* 2008: 3–4

172) Pérez-Gómez 2007: 13

173) Polanyi 2010: 18

174) Derrida 2001: 352

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ORCID iD Otto Paans:
https://orcid.org/0000-0002-9673-998X

ORCID iD Ralf Pasel
https://orcid.org/0000-0003-2728-7470

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