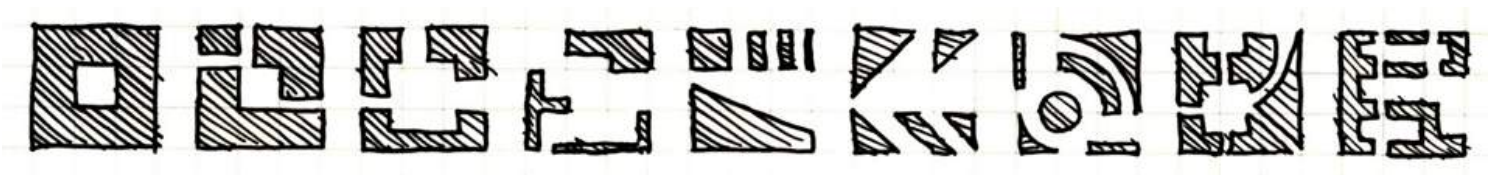
ARCHITECTURAL INTELLIGENCE

FROM PATTERN LANGUAGES TO PARAMETRICISM
TOWARDS ARTIFICIAL INTELLIGENCE

MASTER THESIS - WESTERLINCK BO - 2MA AR - 2019-2020 - UHASSELT UNIVERSITY, BELGIUM



PREFACE

In front of you is a thesis about architectural intelligence. It is composed of four main parts, namely pattern(languages), parametric design, artificial intelligence and finally a case study of my own master project. The main research question that is addressed throughout the different themes is:
'In which ways can systematic approaches, such as pattern(languages), parametric design methods or architectural intelligence, with (or without) technology, support the architect during the design process, in producing new forms of human-nature intelligence?' How can design patterns be used as a way to support designers in complex design processes? How does it guide the design process towards the outcome? This thesis was developed within the completion of my Architectural Masters Degree at the University of Hasselt, located in Diepenbeek, Belgium.

Hereby I would like to thank the people who contributed to the development of this thesis. First and foremost, this is my thesis supervisor, Liesbeth Huybrechts, who guided me through the entire research process, gave me targeted feedback and overall good advice. I would also like to thank our design studio supervisors Maria Segantini, Eef Boeckx & Jo Berben for providing weekly feedback on our master project and further tips to improve our designs. Without the help of these people this work could not have been the same. Finally, I would also like to thank my family and friends who have supported me throughout this whole process.

Bo Westerlinck

Diepenbeek, 2020

ABSTRACT

The past years the task of being an architect has become more complex than ever; the different kinds of regulations that have to be taken into account, the rapidly evolving construction techniques, the ever-changing and multifaceted society, etc... In order to combine all of these different aspects into qualitative architecture, it can be helpful to use some kind of systematic approach, a generative handbook or overall guiding principles that support our design process or could optimize our daily work-flow. Thus I am really intrigued by all the possibilities that systematic approaches (such as pattern(languages), parametric design methods or architectural intelligence), with (or without) technology, have to offer for us as architects. How can design patterns be used as a way to support designers in complex design processes? How does it guide the design process towards the outcome? This research specifically focused on how natural patterns can be used during a parametric design process in order to achieve new forms of human-nature intelligence.

MAIN INTRODUCTION

In front of you is a thesis about Architectural Intelligence. It is composed of four main parts, namely pattern(languages), parametric design, artificial intelligence and finally a case study of my own master project.

The past years the task of being an architect has become more complex than ever; the different kinds of regulations that have to be taken into account, the rapidly evolving construction techniques, the ever-changing and multifaceted society, etc… In order to combine all of these different aspects into qualitative architecture, I think that it is helpful to use some kind of systematic approach, a generative handbook or overall guiding principles that support our designing process or could optimize our daily workflow.

Thus I am really intrigued by all the possibilities that systematic approaches, with (or without) technology, have to offer us as architects. How can design patterns support our (parametric) design process in producing new forms of human-nature intelligence? How can design patterns be used as a way to support designers in complex design processes? How does it guide the design process towards the outcome? Since March 2019 I have been working as a student at an architectural firm 'Architects in Motion'. Here I came into contact with all kinds of innovative techniques and ways of thinking to support the design process (e.g. Virtual Reality, 3D printing, optimizing work-flow, etc..). Furthermore during my international internship in Sydney at LAVA - Laboratory for Visionary Architecture I was also emerged in these digital tools (e.g. parametric modelling Grasshopper & Rhino, one render set up to test out several design options, etc...).

During my studies, I have thoroughly researched the theme pattern(languages). I interpret design patterns as a kind of design principle that can be applied in different places, always adapted to the local context and the wishes and needs of future users. This is a very flexible medium to think about architecture. In addition, the graphic character provides many participatory possibilities, as it is understandable for way more people than just professional designers.
I would like to investigate how parametric design methods could become the next step in this systematic approach of architecture. Finally, it is my ambition to explore several theories about architectural intelligence and what possibilities this could offer us in the future. I would like to emphasize that this research is only focused on supporting the architect during the design process and to offer more possibilities in this. It is absolutely not the intention to let the design process be done by computers alone, but it is simply a way to test options more quickly, each time with a global coherence.

This way of thinking is something I have already applied in several projects during my study, but this was always in an urban context surrounded by a built environment. This year my project is situated in the nature reserve 'Ten Haagdoorn Heide' and 'De Teut'. It is my goal to connect people back with nature and each other, through architecture and architectural patterns more specifically. **I will try to challenge myself to convert the parameters found in nature into a concrete architectural project. For this reason I will thoroughly investigate which patterns can be recognized in this nature and which natural elements play an essential role during the design process. Subsequently, I will define a global strategy for the entire nature reserve and design several pavilions at strategic places focussing on different experiences. The organization of these pavilions is a direct translation from the density of nature, on that specific location, to the density of architecture.**

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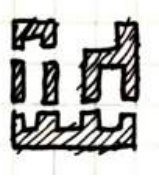

PATTERN LANGUAGES

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OWN MASTER PROJECT

INTRODUCTION PATTERN(LANGUAGES)

Considering that the design process has become more complex than ever these last years, it is very important that all aspects are taken into account during the design process in order to design a qualitative building tailored to the future users. This happens almost unconsciously when one uses a schematic representation of the problems and possible solutions in a specific context. I also try to implement this in my own projects, by using certain design principles/patterns I design very flexible projects tailored to the future occupants and context. This is the reason why I like to delve further into the theory of patron languages (Alexander, 1977) in order to be able to make optimal use of this. Thus I will study the concept of pattern(languages) from a 'design through research' point of view specifically. How they can be used during the design process or within a certain context for instance.

However, fter studying the most important authors (Christopher Alexander, 1977) and concepts (Kevin Lynch, 1960) concerning pattern languages, it remains theoretical and rather superficial knowledge rather than something that can be used effectively during the design process. There is a lack of clear classification and categorization of these patterns. Several authors have already tried to respond to this and refute the critiques that have appeared (Dawes, 2017).

However, the way in which the concept of patterns is interpreted remains very personal. Not everyone finds a certain pattern equally useful or interesting. People have already tried to provide an answer to how, as a designer, one can make a link between the different patterns and how one can categorise them in order to create a kind of 'design guide' that one can effectively use (Park, 2015). The way I interpret patterns is as a kind of design principle (Braun, 2008) that can be used in which some parameters are already fixed but the rest can still vary depending on the context, wishes of the future users,... By using these flexible 'patterns', a design can easily be adapted and often also flexibly be filled in within a certain framework (Lommée, 2013).

Furthermore, I believe that when patterns are used, it becomes graphically very understandable for a wider audience instead of just designers, architects or urban planners. This participatory side of pattern languages can have a huge influence on the quality of a project, tailored to the future residents. I think that's something we all strive for as (future) architects.

This chapter will first set out an analysis of the existing theory of pattern (languages). Subsequently, the trilogy of which 'A Pattern Language' (Alexander, 1977) is only a part, will be investigated more in depth and the published critiques will be identified. The knowledge obtained is then classified in a global pattern language structure in order to finally arrive at a deeper insight into the theory and to form the conclusion.

When researching the first theme pattern(languages), the natural context of the final chapter, which is a case study of my own design project, is always kept in mind. Are there already theories that take into account both an urban and natural context or use natural elements as a guiding principle? Or are the patterns mainly focussed on materiality and technical features, in stead of on the more human and natural possibilities.

PATTERN(LANGUAGES)
1. ANALYSIS THEORY

In this analysis of the theory first a global introduction about pattern(languages) and an adaptive design method will be discussed. Afterwards the key authors; Christopher Alexander, Kevin Lynch, John Habraken and Jane Jacobs, will be thoroughly analysed.

1.1. INTRODUCTION PATTERN(LANGUAGES)

The use of pattern (languages) in both architecture and software is a tool that has been used for several years . Often the design assignment and the process itself are extremely complex. **By working with patterns we can display the problem and possible solutions in a graphical way.** This makes it understandable for more people than just architects, urban planners or other designers. Moreover, the listing of all the different problems ensures that all aspects can be combined into one total solution that contributes to the quality of the environment.

So what is a pattern language? **A pattern language contains rules for how human beings interact with built forms.** It codifies the interaction of human beings with their environment, and determines how and where we naturally prefer to walk, sit, sleep, enter and move through a building, enjoy a room or open space, and feel at ease or not in our garden. The pattern language is a set of inherited tried-and-true solutions that optimize how the built environment promotes human life and sense of well-being. It combines geometry and social behaviour patterns into a set of useful relationships, summarizing how built form can accommodate human activities.

A form language, on the other hand, consists of geometrical rules for putting matter together. It is both visual and tectonic, traditionally it arises from the available materials and their human uses rather than from images. Different form languages correspond to different architectural traditions, or styles. The problem is that not all form languages are adaptive to human sensibilities. Those that are not adaptive can never connect to a pattern language.

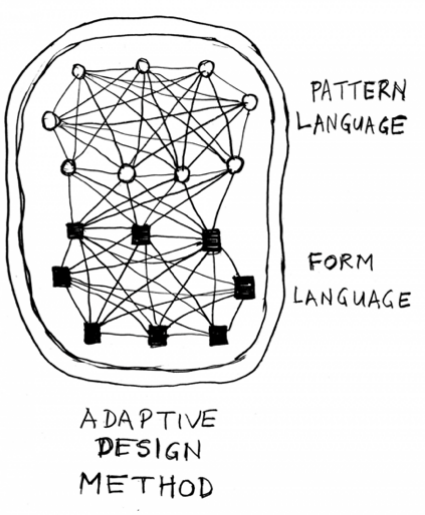


Figure 1.2. Adaptive Design Method

1.2. ADAPTIVE DESIGN METHOD

Every adaptive design method combines both a pattern language with a viable form language. They have to be united into one total design which best fits human needs. If one of both is flawed, then the design method will fail to create adaptive structures. For instance skyscrapers placed in open urban spaces satisfy neither a pattern language nor a form language. They are iconic design failures that only get repeated because architects earn a lot of money building them. For instance the unfinished skyscraper Torre David located in Venezuela that has become an adapted slum settlement (Salingaros, 2014). People apply a pattern language every day to build their own homes, because they want them to be as comfortable as possible. We can call this an adaptive design method, humans need to adapt a building through form, surface and ornament is innate. Some modernists were also very interested in using parts of a form language of rich detailed materials, but nevertheless they created alien forms. The surfaces are adaptive in these examples but the geometry is not.

As mentioned in the previous examples, **an adaptive design method helps to provide the means of creation, but not the final design itself. It is simply a framework or tool for creative expression.** A talented architect or sensitive non-architect still needs to use the language to design a real building and working with this method just makes it considerably easier. Great architects can use an existing form language in an innovative way to create new architectural expressions or they can invent their own form language, this in order to make the future users feel at ease in their designs. Or one can provide building parts to the future residents so that they are able to compose and build their own home (Lommée, 2014).

PATTERN(LANGUAGES)

1. ANALYSIS THEORY

1.3. KEY AUTHORS

1.3.1. CHRISTOPHER ALEXANDER - 'A PATTERN LANGUAGE', 1977

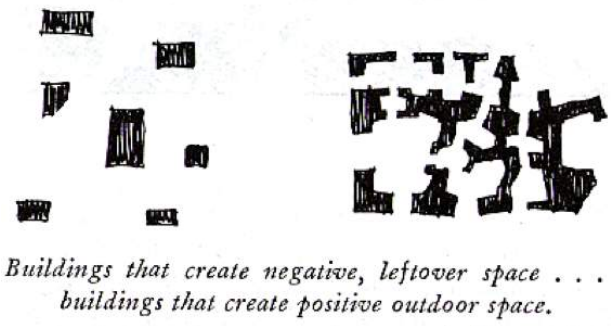


Figure 1.3. A Pattern Language Example 'Buildings that create negative, leftover space... Buildings that create positive outdoor space.'

One of the most influential architects and design theorists within the pattern languages is of course Christopher Wolfgang Alexander with the book 'A Pattern Language' (1977). With this book he has had a great influence not only within architecture, but even within the fields of urban design, software and sociology. With the patterns he tries to make a clear enumeration of different possibilities how one can deal with the design of space and architecture on all kinds of scales.

He lists different possibilities about how we can deal with the design of space and architecture on all kinds of scales taking into account human sensibilities. He always displays this in the same and very graphical way. It seems like a generative grammar handbook for architects. Here the designer always has the choice between different solutions, depending on the environment in which the project is situated. In this way, architects have a kind of guiding principle to generate a constructively logical and attractive design on all scales, from complete cities to rooms and even built-in furniture.

However, it should be noted that such patterns need to be tested and commented on in reality by several architects and users. The authors themselves see the patterns as hypotheses and not as infallible solutions. The book 'A Pattern Language' (Alexander, 1977) lists some 253 patterns. First the problem is described and finally a solution is proposed.

This allows everyone to use the patterns to design their own home, street or even community. Observation shows that the greatest places in the world are often designed by the people themselves and not by architects. In addition, an enormous number of references to other numbers of patterns have been used to complement the discussed pattern.

Some patterns really focus specifically on materials, such as reinforced concrete, as it could become one of the best materials in the future with the help of modern technology. Other patterns focus on different life experiences. The book has a special focus on human rights such as freedom and explores in a design way how design can improve this for an individual.

PATTERN(LANGUAGES)

1. ANALYSIS THEORY

1.3. KEY AUTHORS

1.3.2. KEVIN LYNCH - 'IMAGE OF THE CITY', 1960

This book was published in 1960 by the American urban theorists Kevin Lynch. It deals with how people observe the information of a city and translate this into a mental map.

From his 5-year study, he could conclude that most people rely on five elements when observing a city. The first elements are the 'Paths', these are all kinds of streets, walking paths, canals and other elongated structures that organize the space and generate movement between different spaces. Then he describes 'Edges', which includes all kinds of boundaries, which can be both real or mere sense and a boundary. Specifically, these are walls, buildings, coastlines, etc...
Large two-dimensional areas he names as 'Districts'. Here individuals can either enter or leave and they have clear characteristics that distinguish them from each other. The fourth defined element are the 'Nodes'. This refers to the nodes where the centre of the city or neighbourhood meets. Often we can view the aforementioned from here. The fifth and final element are the 'Landmarks' as a fifth element, these serve as reference points within a city, but usually it is not possible to enter them. These can be buildings, public art, mountains or even mobile points such as the sun.

Figure 1.3.2. The Five Elements of Kevin Lynch

PATTERN(LANGUAGES)

1. ANALYSIS THEORY

1.3. KEY AUTHORS

1.3.3. JOHN HABRAKEN - 'STRUCTURE OF THE ORDINARY', 1998

Nikolaas John Habraken is a Dutch architect, theorist, author and also professor of architecture at various technical universities. **He mainly focuses on how residents can participate in the design of mass housing.** It is therefore the intention that citizens actively participate in the design process. He has translated his theory into a visual result called 'Structure of the Ordinary'. Internationally, he is even seen as one of the most important protagonists that stimulate this participatory process. All his realized projects are therefore tests on this theme with a focus on participation of the citizens themselves. Habrakens' way of thinking has led to highly influential architectural projects worldwide, for which he has received various architectural awards, both nationally and internationally.

What is special about Habraken is that he makes a distinction between 'Everyday' and 'Special' architecture. He chooses to focus on the former. This is also sometimes called 'High culture' and 'Low culture' within architecture. These two are present in every city. **In contrast to Christopher Alexander (A Pattern Language, 1977), he has deliberately chosen not to include images. According to him, it is the task of the architect to translate his theory into effective designs.**

For example, architect Ottokar Uhi chose to work with the principle 'Structure and coincidence' or 'Structure and infill'. Using this principle, the resident can fully adapt the 'installation' of the 'hull' to his own wishes and needs. This ensures that the adaptation costs are limited in the future, as an intelligent ruin is used (Bob Van Reeth, 2010). Tastes can be very different, in the past only the elite had the possibility to determine architecture, through this participation movement everyone gets a chance to make their ideals reality. This also refers back to the subdivision he makes between 'Everyday' and 'Special' architecture.

The well-known architect Herman Hertzberger adds that the latter must remain intact and that nothing may be added to it. In general he has no problem with this when it happens to other buildings, but he is of the opinion that the work of great architects should be respected.

In addition, this participation ensures that professionals and non-professionals work together. This was rarely the case in the past. Sometimes, however, conflicts can arise when there is a too extreme form of participation on part of the residents. After all, housing construction is in direct contact with public space. This raises the question of how far one can and may go so that this does not result in an unacceptable visual appearance. The result is an enormous variety of styles. The art is therefore to set certain limits so that a kind of unity is created without restricting the freedom of the residents (Lommée, 2016).

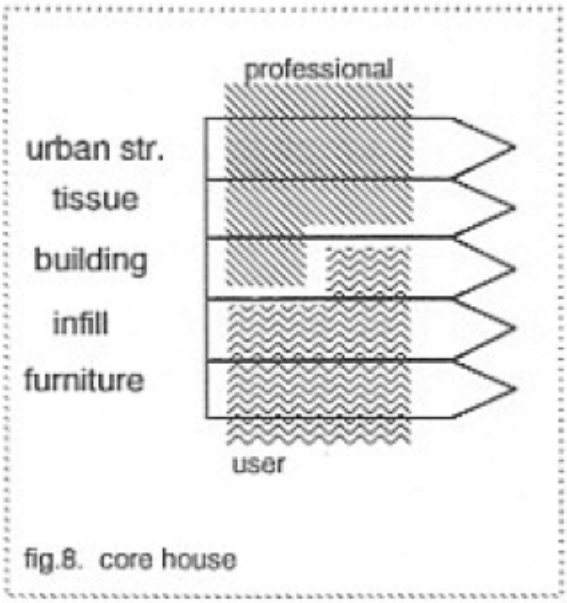


Figure 1.3.3. Core House by John Habraken

PATTERN(LANGUAGES)

1. ANALYSIS THEORY

1.3. KEY AUTHORS

1.3.4. JANE JACOBS - 'THE DEATH AND LIFE OF GREAT AMERICAN CITIES', 1961

Jane Jacobs, actually born as Jane Butzner, was a publicist and city activist. Her fame mainly comes from her plea for hybrid living environments. She was therefore absolutely against the development of monotonous residential areas, for example. According to her, a city needed all kinds of mixed functions to create a dynamic city (Jacobs, 1961).

In her famous book, 'The Death and Life of Great American Cities', she unveiled the important mechanisms that allow a city to function, which threatened modernistic approaches to urban planning/zoning. Considering that their main goal was to separate functions as working, living and traffic as much as possible.

She substantiated her vision with a common sense, namely that a dynamic city must possess various functions in order to achieve a lively streetscape. When neighbourhoods have multiple functions, these dynamics are created automatically by the people who are active in them and exchange between them. Therefore in order to attract as many people as possible to a particular city, it is very important to offer a variety of functions, in other words, a high density of activities, such as intensive street use and high-rise buildings (Jacobs, 1961).

In her opinion, it is also useless to demolish old buildings, because they can be used by activities that have less economic resources and therefore cannot opt for new construction. This to ensure that the intensive use of the neighbourhood would certainly not be jeopardised by the possible oversupply of new buildings. As a designer, according to Jane Jacobs, the human scale must always be taken into account; it must be both the measure and driver of urban development.

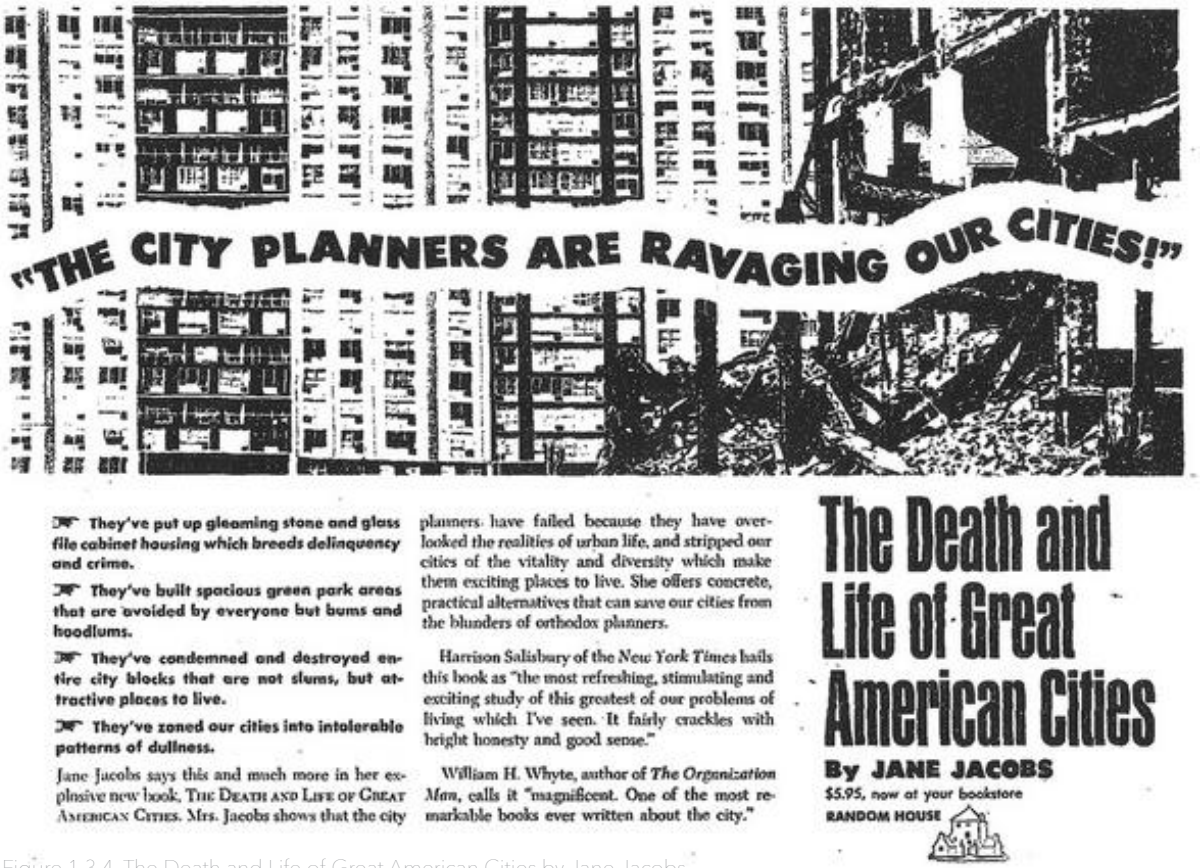


Figure 1.3.4. The Death and Life of Great American Cities by Jane Jacobs

PATTERN(LANGUAGES)
1. ANALYSIS
1.4. CONCLUSION
PATTERN(LANGUAGES)

Previous research on key authors within the development of pattern(languages) in architecture has led us to conclude that each of them uses his or her own working method in drawing up the work. Habraken prefers to work autonomously in designing patterns without first observing them and without graphically representing them. Kevin Lynch, on the other hand, is very much based on observation. He summarizes these into mental maps in which five determining elements are dealt with, which are also represented graphically. Lastly, Christopher Alexander also works in an enormously graphic way to clarify his 253 listed patterns. In doing so, he constantly refers to the various links between them.

All authors assume that these patterns are merely hypotheses of possible solutions for certain contexts. However, these need to be tested, adapted and experimented with several times in reality. I myself can find the most connection with the graphic representation of patterns (languages) (Christopher Alexander, 1977; Kevin Lynch, 1960). In my opinion this is the clearest and most readable for both architects and people who are not at home in the design world. In the last chapter about my own design project you will see that this graphical way of experimenting with patterns is my preferred method.

Furthermore, I understand that it is possible to design patterns without first observing (John Habraken, 2000), but it seems to me that it is certainly appropriate to make use of this. If you really want to design something for a complex reality and take all the different aspects of this specific location into account, you really need observation in order to really get all these elements. This to prevent that certain important image-defining elements are overlooked.

In addition, I believe that many interesting patterns (languages) have already been developed by many more people than just these three key authors on which one can work further, such as 'A Post-modern View of Design' (Tom Turner, 1996). It is therefore the task of every architect, urban planner or other designer to work with them in a critical and complementary way.

When mastered, this can be a very useful medium to formulate the best possible solution for almost every complex design task with its associated context.

Since Alexander's method resembles most to my own graphical way of experimenting with patterns I will continue to research this specific way of using design patterns.

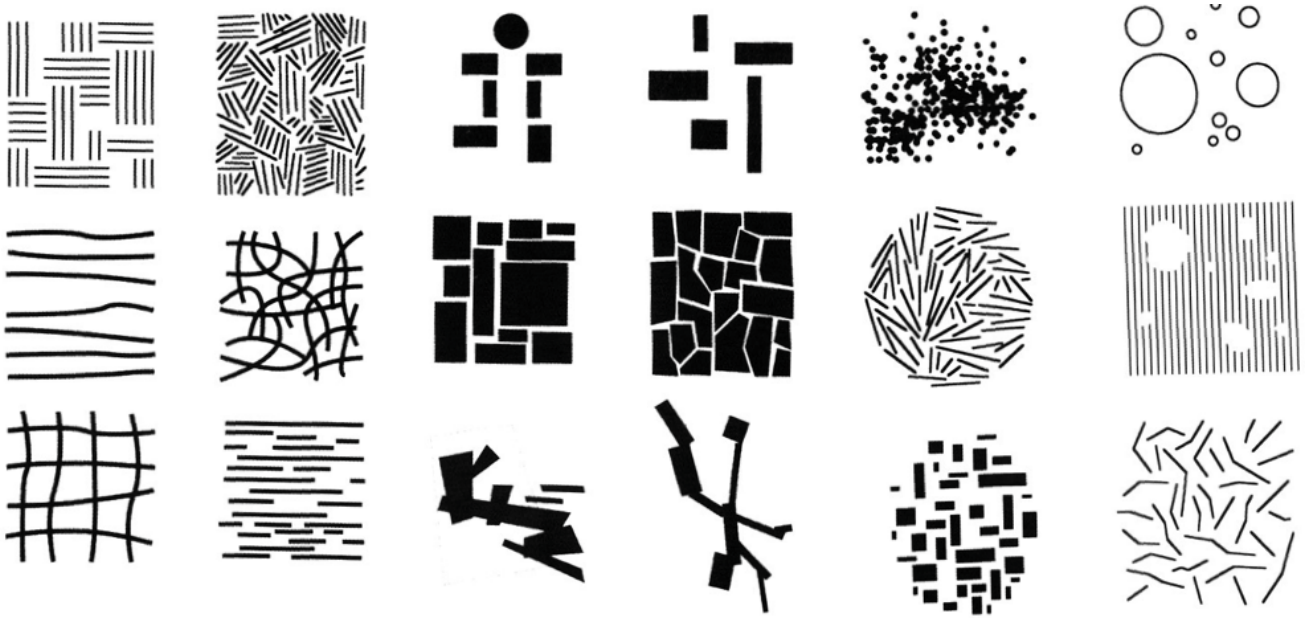


Figure 1.4. Different schematic views of Patterns

PATTERN(LANGUAGES)

2. IDENTIFICATION CRITIQUES

In this chapter the complete trilogy, written by Christopher Alexander will be discussed. Furthermore, the different critiques on his work will be identified into ontological and epistemological problems on three levels. This in order to see the cohesion or links between these critiques published by different authors.

2.1. TRILOGY WRITTEN BY CHRISTOPHER ALEXANDER

During the 19th century, social, technical and economic evolutions lead to the emergence of modernism and the development of some of the most iconic buildings. However, this focus on this new modern aesthetics brought some problems as well, such as; the unpleasant or even inhuman spaces that were designed. To counteract this problem, Christopher Alexander developed three theories that are closely related to each other. This is something that is often forgotten. In fact, it is one major research to which he has devoted his entire career (Dawes, 2017).

2.1.1. NAMELESS QUALITY

The first part, The Timeless Way of Building (Alexander, 1979) is an introduction to Alexander's train of thought in 'A Pattern Language' (Alexander, 1977) and 'The Oregon Experiment' (Alexander, 1975).

He introduces the concept of 'nameless quality', by which he means that it cannot be denied that traditional architecture, based on a kind of common value system, possesses a certain quality. All aspects are combined into one harmonious design, in contrast to some contemporary designs where this is not in balance (Salingaros, 2000). This is in line with the distinction made between 'Everyday' and 'Special' architecture in 'Structure of the Ordinary' (Habraken, 1998). According to him, this is something we should all strive for as designers. For this reason, he tries to draw up a number of informal rules that can be used to achieve this. He cites several examples in order to make this understandable and to encourage us to reflect on it.

Just like his second book, the layout is a bit unusual, it is a list of titles with a short explanation underneath. It was his intention to make it possible to read the book very quickly, even though it has 552 pages. There are also several pages filled with images, either to support his thinking or to clarify the reference in his text.

2.1.2. A PATTERN LANGUAGE

His second theory 'A Pattern Language - Towns, Buildings, Construction' (1977) he tries to replace subjective and conventional theories with an objective theory that directly generates a design (Grabouw, 1983; Gelernter, 2000). A pattern language helps to make complex socio-spatial connections which makes it accessible to more people than just professional designers. This is one of the reasons why this architectural text is one of the most read and referred to (Alexander 1996). However, it often remains merely a reference to the existence of his texts and is little more than an effective deeper insight into what he wanted to achieve with his global theory. This will be dealt with more in detail in the section identification of the published critiques.

2.1.3. USING THE INPUT OF FUTURE USERS/ INHABITANTS

For this book 'The Oregon Experiment' (1975), Alexander worked with Murray Silverstein, Shlomo Angel, Denny Abrams and Sara Ishikawa. As the title says, the book actually describes an experiment in Oregon. The students of the University of Oregon wanted more control over their lives and their environment, for which they started a protest. To try and solve this, the University hired professor Berkeley. This progressive professor from the University of California came up with a design that allowed the students to create their own living environment.

The book describes that this 'feeling' should be one of the main criteria before any changes are made to a space. Good solutions to generic problems, also called patterns, should be available in a kind of encyclopedia. The serious problems should receive the most attention first, and the occupants/users of a space should have a say in its development.

PATTERN(LANGUAGES)

2. IDENTIFICATION CRITIQUES

2.2. CRITIQUES ON THE THEORY OF CHRISTOPHER ALEXANDER

2.2.1. INTRODUCTION CRITIQUES

Many of the published reviews are mainly focused on A Pattern Language (Alexander, 1977), although some authors also discover problems in 'The Timeless Way of Building' and 'The Oregon Experiment'. In order to gain a deeper insight into which critiques have now been published on this theme, they will be systematically explained according to three subdived levels, namely conceptualisation, development and implementation. In addition, the links between the different critiques will also be mentioned, as some are part of a larger more general critique on his theory. Since it is enormously complicated to determine an unambiguous identification of the published critiques without losing information (Dovey, 1990), this is only a proposal for improvement which is set out (Dawes, 2017).

2.2.2. CONCEPTUAL FOUNDATIONS OF THE THEORY

In order to reason about this, a thorough analysis of Alexanders' broader work was first carried out, with a focus on his second work 'A Pattern Language'.

Conceptually, this can be divided into four main critiques that have appeared. The first three of these relate to his inflexible/exclusive world-view and thus focus on ontology, also called the theory of being within metaphysics. The fourth one is focused more on the legitimization of his theory which corresponds with epistemology, also called the theory of knowledge.

Figure 2.2.1. Conceptualisation critiques (on theory of Christopher Alexander)

PATTERN(LANGUAGES)

2. IDENTIFICATION CRITIQUES

2.2. CRITIQUES ON THE THEORY OF CHRISTOPHER ALEXANDER

2.2.2. CONCEPTUAL FOUNDATIONS OF THE THEORY

The first epistemological critique, written by Saunders (2002) and Bhatt (2010), is that his research takes place in a subjective world in which only one thing (nameless quality) matters. In 'The Timeless Way of Building' he refers to a 'quality without a name', which according to him is indisputable to everyone. The idea that all people appreciate the same things is, of course, rather limited. Developing values is something that happens through a combination of human feelings, education and the culture in which someone lives (Dawes, 2017). Human experiences do feel the same but not everyone reacts in the same way to this naturally (Dovey, 1990).

He then sees the world through rather rosy glasses, rejecting alternative lifestyles or other architectural influences. Alexander's ideal lifestyle could be described as easy, comfortable, sensory, communal with lots of time for social interaction (Saunders, 2002). Thus the second ontological problem that Elshestawy (2001) states is that external factors such as, certain rules, morals, fears are not taken into account at all and consequently exclude many political, social and economic realities. Moreover, he assumes that this is the lifestyle that everyone strives for, which is rather short-sighted (Saunders, 2000; Bhatt, 2010). In addition, he continues this narrow view in the fact that, according to him, high-quality architecture comes either from Europe or from himself (Kalb, 2014).

The third ontological problem is that, according to him, beautiful architecture can only be created by using 'The Timeless Way of Building'. One can interpret this critique as a combination of the two aforementioned. Alexander's personal preferences are generalized as an objective standard of beauty. He goes even further, naming people who disagree with this as victims who can no longer see this self-evidences (Kohn, 2002; Saunders, 2002). This inflexible attitude lies at the basis of much of the critiques that have appeared on this theme. Alexander, however, refutes them by mentioning in the introduction to 'A Pattern Language' that he proposes only one possibility of a pattern language and that he urges readers to refine it, adapt it or make their own version of it (Alexander, 1977). So there are many different variations of pattern languages possible.

The last issue, that is formulated by Elshestawy (2001), concerns the development of his theory; namely that he states that his theory is scientific. However, there is still a difference between 'real science' and social findings. It would be better to describe his work as a list of hypotheses (as a kind of urge to investigate it). But he also mentions this in his introduction, namely that he also sees the patterns themselves as a kind of hypothesis. However, many people don't know this and they assume that it is scientific because of his way of writing (Elshestawy, 2001).

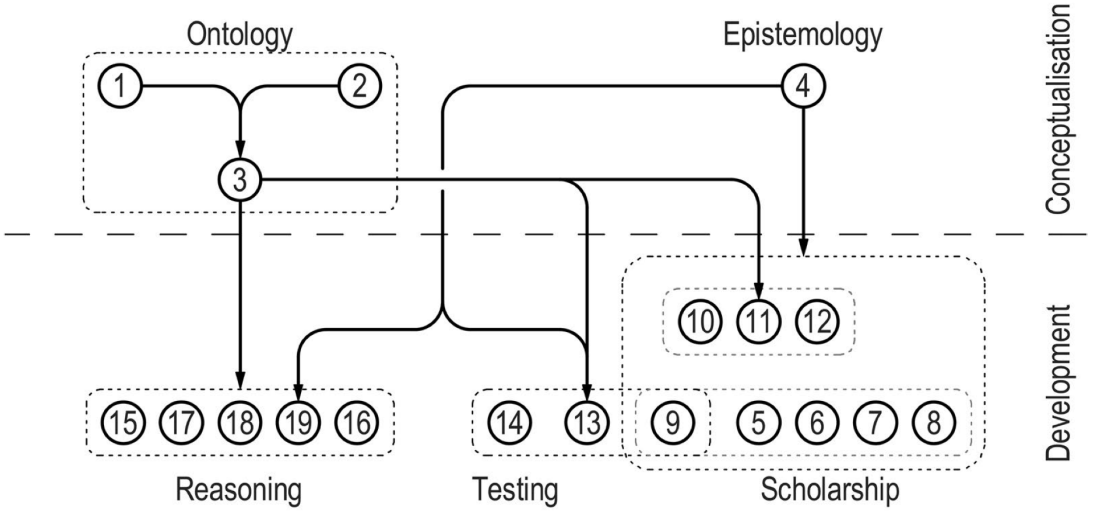


Figure 2.2.2. Development critiques (on theory of Christopher Alexander)

PATTERN(LANGUAGES)

2. IDENTIFICIATION CRITIQUES

2.2. CRITIQUES ON THE THEORY OF CHRISTOPHER ALEXANDER

2.2.3. DEVELOPMENT & DOCUMENTATION

Due to a lack of implementation of the knowledge of professional designers and architects, the development and documentation of his theory is also the subject of much critiques (Kohn, 2002). There is a barrier that prevents architects from making effective use of his patterns. Here we can outline three major groups of possible reasons that explain this.

First, there is a critique on his idiosyncratic approach to science, with the result that there is a lack of real definitions which makes it difficult effectively use his theory. The second group focuses specifically on the term 'empirical' he uses to describe his theory. This builds on the previous critique of science and also reflects the fact that he believes in only one correct way of building.

The last group contains critiques about the development of his theory from some erroneous reasoning, such as the fact that there is only one way to design good architecture. Consequently, the critiques from this second and third group contribute to the further development of the effective implementation and results of his theory (Dawes, 2017).

In addition, his graphic way of presenting patterns sometimes makes it very understandable but sometimes also very confusing (Kohn, 2002). They are rather unclear or poorly substantiated/explained and without examples. This creates a lot of doubt as to how architects should interpret and adapt them in order to create high-quality architecture (Kohn, 2002).

Moreover, Jane Jacobs and Bernard Rudofsky dealt with similar problems (experimenting with patterns) but he consciously isolated his theory completely from their research (Kohn, 2002). Rudofsky's research 'Architecture Without Architects: A Short Introduction to Non-Pedigreed Architecture', dealt with a sustained argument for humane and sensible design. He was convinced that modern architecture got out of touch with the sensuality and needs of mankind. According to Jane Jacobs there are two factors that promote creativity and develop new ideas: namely a diverse range of knowledge and technology and the second one is the willingness of creative inhabitants of that city to link this knowledge and technology.

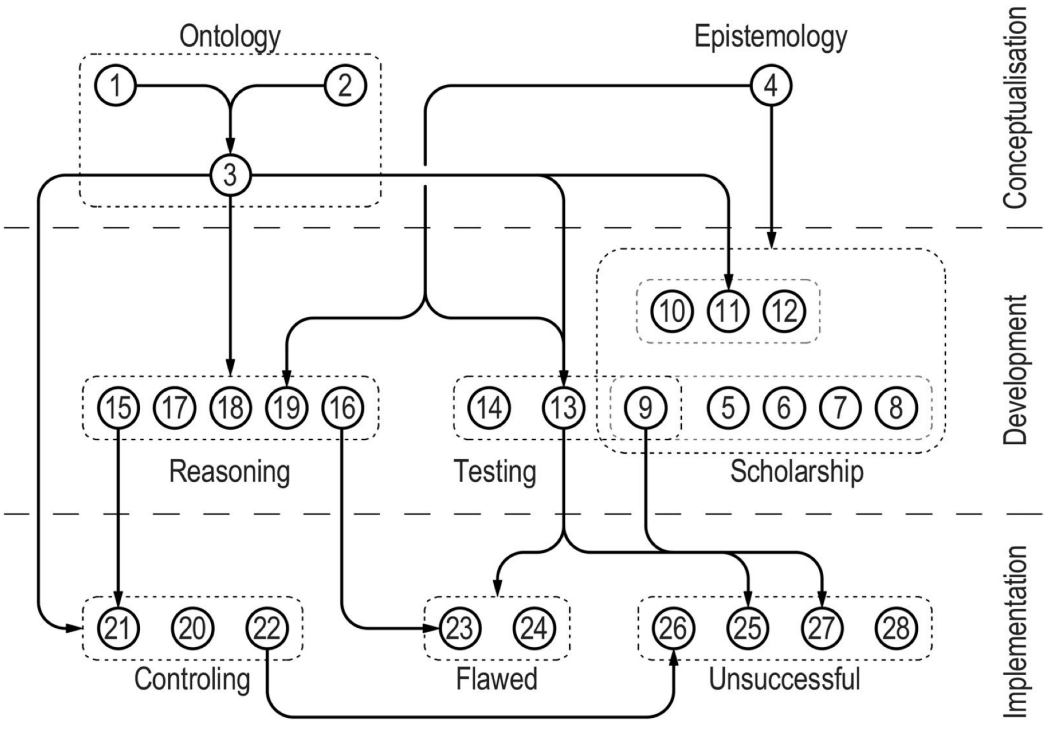


Figure 2.2.3. Implementation (on theory of Christopher Alexander)

PATTERN(LANGUAGES)

2. IDENTIFICIATION CRITIQUES

2.2. CRITIQUES ON THE THEORY OF CHRISTOPHER ALEXANDER

2.2.4. IMPLEMENTATION & RESULTS

The last part of the published reviews can be divided into three groups.

The first group also builds on the fact that according to him there is only one right way to build. Next, the second group deals with errors in individual patterns, which are actually a consequence of the conceptual foundations of his theory (Gelernter, 2000). The third group argues that his theory does not allow the effective design of 'quality without a name' and also includes the fact that Alexander ultimately rejected his own theory. It is in fact possible to obtain this quality without using patterns and vice versa one could still generate inhuman and ugly designs when using them.

Moreover, the pattern(s)(languages), which provide solutions that are both physically and psychologically satisfactory and at the same time coherent, can also limit designers in their freedom (Salingaros, 2000; Kalb, 2014). Alexander's theory sees creativity rather as a way to adapt his patterns to a specific context in order to generate unique designs instead of really encouraging designers to formulate new solutions themselves. (Alexander 1967,1977; Salingaros, 2000).

2.3. CONCLUSION

We have discussed different authors' critique on the work of Alexander, in that perspective it is of great importance to be able to place the second and also best known text 'A Pattern Language' written by Alexander in relation to his whole body of work. It is part of a trilogy and is therefore not a work in itself. Timeless Way of Building' is a kind of introduction to this and 'The Oregon Experiment' is a real test to see if his theory works effectively. This is crucial to be able to gain an understanding in his way of thinking.

In addition, the critiques visible in the diagrams (Figure 2.2.1., 2.2.2. and 2.2.3.) are all closely related and some are also a consequence or further explanation of a similar critique at a higher level (Dawes, 2017). But in general it is often about the fact that Alexander can be rather short-sighted about the 'nameless quality' he talks about and that there are still some thresholds for designers that make it difficult to make effective use of his patterns. However, this was originally his goal, to create a kind of generative handbook for architects that was easily adaptable to a specific context. Exactly by abstracting it to generic problems, and by leaving the more specific behind, Alexander tried to encourage other designers to adapt his theory to their own preferences and way of working.

So we can conclude that as a designer it is essential to gain insight into all three parts of the trilogy as well as all three levels of criticism that have appeared concerning his whole body of work before one can actually gain a deeper insight into it. When one is aware of some incompleteness within a global theory one can take this into account or perhaps even formulate small iterations or changes for it.

PATTERN(LANGUAGES)
3. CLASSIFICATION KNOWLEDGE

In the previous chapter we have analysed what the concept of pattern languages is and how they can be used according to the key authors (Alexander, 1977; Lynch, 1960; Habraken, 1998; Jacobs; 1961). Furthermore, we identified the various critiques that different authors published about his whole body of work (Bhatt, 2010; Dawes, 2017; Dovey,1990; Elshestawy, 2001; Gelernter, 2000; Kalb, 2014; Kohn, 2002; Salingaros, 2000; Saunders, 2002). Next, we will look at how those patterns can work together or be classified, either within a global network of patterns; i.e. a pattern language structure or as main patterns each time with their main contributors, to which reference is made or as different groups or species of patterns.

The patterns are the building blocks and by placing them in a certain structure we will determine the relationship between the different patterns. Park (2015) and Winn (2014) have tried to classify the relationship between the different patterns in three different ways, first in a very logical way by creating a kind of tree trunk structure of main patterns and their main contributors. Another way is to link a pattern to several other patterns within a global network of patterns also called a pattern language structure. Lastly different kinds or species of patterns can be grouped together.

3.1. PATTERN LANGUAGE STRUCTURE

Pattern languages are a kind of structured mechanism that describes some good design rules of thumb, these are the patterns. By using network analysis, we can quantitatively determine the relationships between the different patterns, but also the importance of each individual pattern. This results in a web of networks that illustrates how the patterns are interconnected and clustered (Park, 2015). According to Park we determine the relationship between the different patterns quantitatively, but as a designer you are more likely to determine this relationship qualitatively during the design research process. If one gains sufficient insight into this as a designer, one has the possibility to compile one's own 'design guide' by using a combination of the patterns (languages) and social network analysis.

Christopher Alexander himself also assumed that one could use his patterns as a kind of structure, since he links each pattern with the other relevant patterns (Salingaros, 2005). Thus, in each chapter he already groups together the coherent patterns that are all linked to one main pattern. At the bottom of each pattern he also mentions the smaller links to other patterns. As a designer one can choose to use only one pattern for a simple design assignment, as opposed to a more complex assignment in which a group of patterns has to be used. These links between the patterns can be, among other things; the essential basis of the completeness of another pattern, an addition to a certain pattern, or both of the aforementioned.

In addition, the patterns support each other when one uses a certain family of patterns which creates a synergy, which also makes it easier to use these connected patterns together (Park, 2015).

The main purpose of this pattern structure is to enable designers to follow a logical design process in which the patterns are converted into empirical projects in which all aspects are combined into one high-quality overall design.

PATTERN(LANGUAGES)

3. CLASSIFICATION KNOWLEDGE

3.1. PATTERN LANGUAGE

STRUCTURE

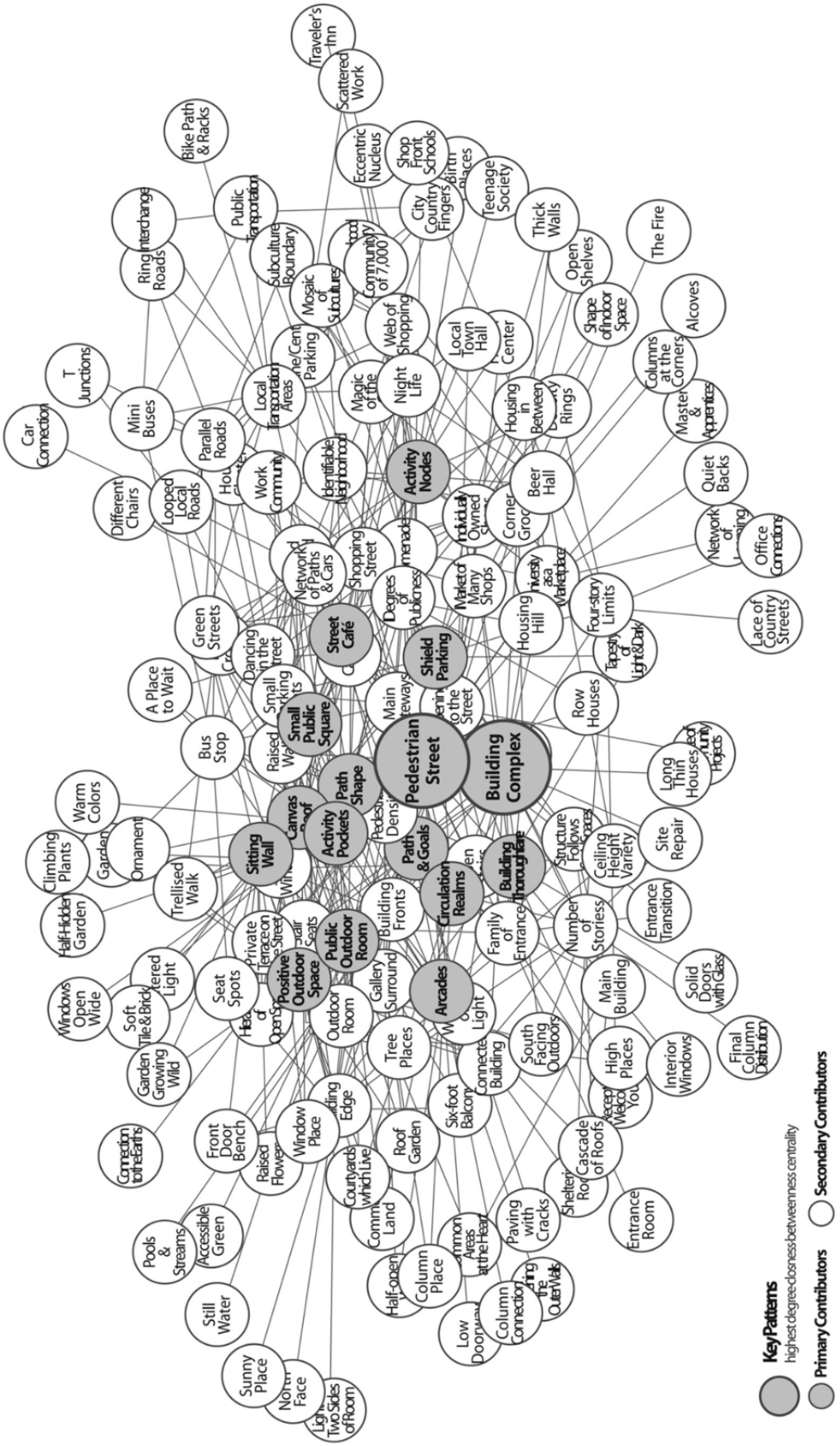


Figure 3.1. A Pattern Language Structure

PATTERN(LANGUAGES)

3. CLASSIFICATION KNOWLEDGE

3.2. MAIN PATTERNS & MAIN CONTRIBUTORS

In addition to placing patterns in an entire network or pattern language structure, they can also be seen as a few main patterns with their main contributors each time. Here we will discuss how, for example, Park (2015) has subdivided them into; whole inner city, spatial reorganization, clustering related forces, fragmented growth, local symmetries, cross-links, local repair, void.

3.2.1. WHOLE INNER CITY

As mentioned earlier, network analysis was used to determine how important or how often a pattern is used (Park, 2015). This showed that 'pedestrian streets' and 'building complexes' were the two most frequently used nodes within the example of an entire inner city. Although the second may not seem so important for urban design, for example, it plays a very important role in connecting the most important patterns, which for the rest have few other links. If such a node is not noticed, it may be that the entire system covered by it also functions less well or even poorly (Park, 2015).

This is of course something we absolutely want to avoid, and is the reason why it is so important to understand the complete pattern structure well as an architect or designer.

3.2.2. SPATIAL REORGANISATION

The second analysis, that was carried out, showed that, for urban infrastructures, the nodes of various activities were particularly important (Park, 2015). Next, for the street level, it was mainly the footpath and its shape that was very decisive (Park, 2015). The next level relates to 'interface design', which focuses on anticipating what users might want to do somewhere and need to do it. These turned out to be the most important junctions; sitting wall, building fronts and arcades (Park, 2015). Finally, on the scale of the buildings themselves, the building complex was again the most important. In the table below you can clearly see this subdivision into nodes, classified according to the two main analyses that were carried out.

Key patterns	Primary contributors	
Whole downtown		
Pedestrian Street	Activity Nodes	Path Shape
Building Complex	Activity Pockets	Positive Outdoor Space Public
	Arcades	Public Outdoor Room
	Building Thoroughfare	Shielded Parking
	Circulation Realms	Sitting Wall
	Canvas Roof[a]	Small Public Square
	Path and Goals	Street Café
Spatial reclassification		
Urban structure		
Activity Nodes	Identifiable Neighborhood [a]	Promenade
	Local Transportation Areas	Public Outdoor Room
	Network of Paths and Cars	Small Public Squares
	Pedestrian Street [a]	
Street		
Pedestrian Street	Activity Pockets [a]	Shopping Street
Path Shape	Building Thoroughfare	Something Roughly in the Middle
	Path and Goals	
Interface		
Sitting Wall	Building Edge	Positive Outdoor Space
Building Fronts	Canvas Roof	Stair Seats
Arcades	Opening to the Street	Street Café
Building		
Building Complex	Circulation Realms	Main Entrance[a]
	Corner Grocery	Number of Stories
	Four-story Limits	Shielded Parking

[a]Indicates patterns were not chosen as source patterns, but appeared with a high centrality score.

Figure 3.2. Key Patterns and Primary Contributors

PATTERN(LANGUAGES)
3. CLASSIFICATION KNOWLEDGE
3.3. DIFFERENT KINDS OF PATTERNS
3.3.1. CLUSTERING RELATED FORCES

In addition to determining the main patterns and their main contributors, the patterns can also be subdivided into 6 species (Winn, 2014). We will briefly discuss these to provide a clear overview.

First one has the clustering of related forces. **When there are too many aspects, they try to cluster all those that are related to each other (Winn, 2014).** This with the aim of making it easier to think about the different clusters. When, for example, a design task is so complex, one can subdivide all the aspects one wants to combine and then reflect on a suitable solution for each of them. Of course, the links between them should not be forgotten.

3.3.2. FRAGMENTED GROWTH

When a new structure needs to be added to a certain system, the best way to do this is one by one. Because in this way one can always evaluate the effect on the existing structure and possibly adjust it when needed (Winn, 2014). In this way, a homogeneous system can be obtained that functions as one. In addition, it is much better when a system evolves instead of immediately being changed drastically. This ensures that the overall stability is maintained. Since the adjustments are based on what worked in the past instead of anticipating what might happen in the future.

3.3.3. LOCAL SYMMETRIES

If the system structure is still too coarse-grained, this means that the system is too coarse-grained. To work this out, we use a finer structure to break the symmetry in the domain of implementation (Winn, 2014). This applies, for example, when one has to design a system for which implementation is certainly not self-evident. To be able to respond to this, we need to thoroughly analyse the existing system up to a certain level. This allows us to focus certain parts of the system specifically on certain tasks.

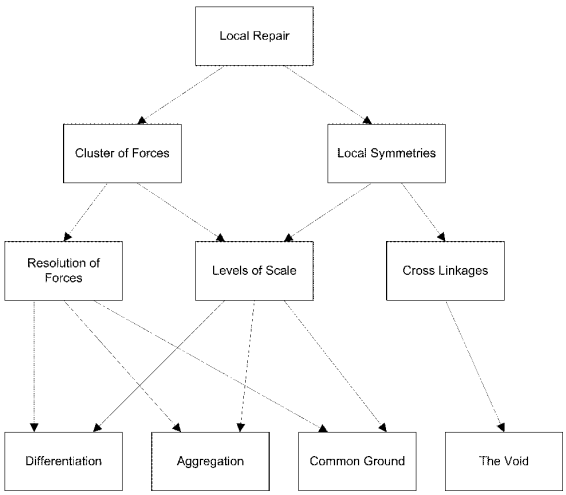


Figure 3.3. Different Kinds of Patterns

3.3.4. CROSS-LINKS

When a certain system is too complex, use overlaps and cross-links to make this complexity understandable (Winn, 2014). Very complex structures cannot be visualized in simple diagrams such as tree diagrams because there are many overlapping parts. These are just as crucial, one can for example display them in a half-grid in which the overlaps can also be made visually visible. The most important limitation is that when two overlapping sets belong to the set, the set of elements common to both also belongs to the set (Alexander, 1964).

3.3.5. LOCAL REPAIR

When a system has a particular area that requires extra attention, reinforce this by reintroducing the middle of local symmetries already present in these areas (Winn, 2014). When something is changed or repaired on a certain system, it is guaranteed to affect the rest of the system. How can this be done in the best possible way so that the rest of the system is disturbed as little as possible. For example, one can start by taking over the existing structure and suggest a possible interpretation. When one notices that this does not work well, this structure can be emptied again and then filled in with a better solution.

3.3.6. VOID

When a certain system has become too entangled, remove/empty a certain part which makes room for further development (Winn, 2014). Applying local repair here would make the system even more complicated. We can make the nodes understandable by interrupting some connections in the system and allowing new growth. Natural processes also work periodically by cleaning when they have become too much in the knot. For example, forest fires regenerate forests to their original form.

PATTERN(LANGUAGES)
3. CLASSIFICATION KNOWLEDGE
3.4. CONCLUSION CLASSIFICATION

First of all, we have to keep in mind that the patterns work in a pattern language structure. Different related patterns work together in a network in order to generate a suitable solution for a specific problem. This is also the way Alexander wanted them to be used. For this reason, he divided his 253 patterns into several chapters and referred to other additional links at the bottom of each pattern.

Subsequently, a network analysis of the existing patterns showed that on different scales, from urban to user scale, important nodes were recognizable between the most frequently used patterns (Park, 2015). These can also be referred to as the main patterns, each with a few primary contributors. Although these sometimes did not seem so important, they nevertheless played an enormously crucial role in the global system.

Finally, different types or species of patterns are also recognisable within this large pattern structure (Winn, 2014). These can also be seen as possible solution strategies that can be applied when a certain problem occurs in a coherent system. The six different 'methods' that are offered ensure that one has a basis for making adjustments to a certain system. Furthermore it is always assumed that a certain solution first needs to be tested to analyse the impact on the overall system. If necessary, this can then be adjusted before disrupting the entire system.

It is very important to draw up this classification of the existing knowledge of patterns (languages). This is in order to maintain an overview of the complex pattern language structure and to choose the right solution strategy when a specific problem occurs. This to be able to make effective use of it for yourself and for others.

We can agree with the previous authors Winn (2014) and Park (2015) that patterns work best within a network or system of additional patterns and that when describing a pattern language it is best to mention the links between the different patterns in order to help the readers understand your way of thinking about them.

Considering that each designer has it's own values, preferences, morality, culture we have to take into account that the choices, that are made during the design process (using patterns), are influenced by this. Exactly by communicating very open about why you made certain choices during the design process, allows others to reinterpret this. If for instance they didn't agree with a certain choice you made along the way, they can change this or to even continue working on this in a similar way you've dealt with it. This is precisely what I have tried to do in the final chapter about my master project, in which you can see all the different design experimentations I made during the entire design process.

In short, communicating very transparently why certain choices where made during the design process, within a system of patterns, is a lot more valuable than trying to create a generic solution with a universal logic. This is a constant balancing act between the universality and keeping flexibility.

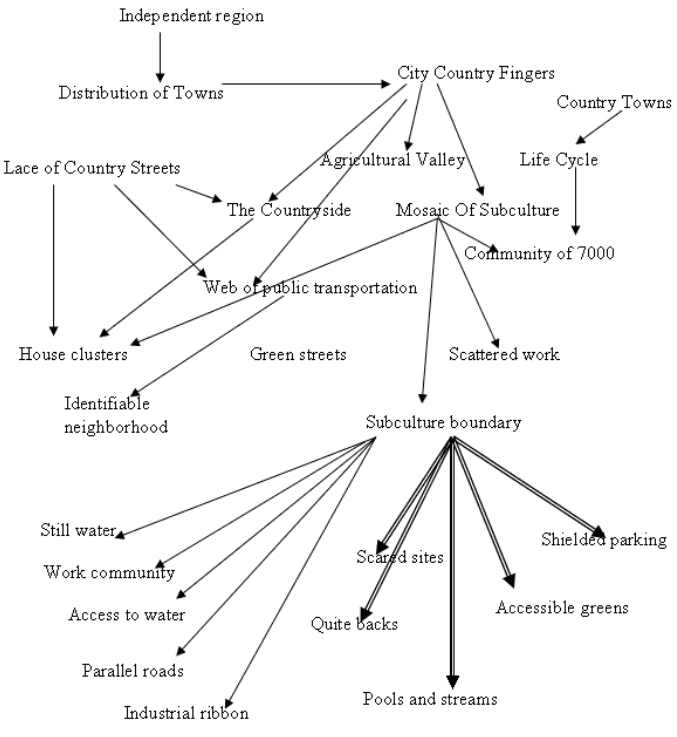


Figure 3.4. Structure of Patterns

CONCLUSION PATTERN(LANGUAGES)

We can conclude that each adaptive design method combines both a pattern language and a form language. It is therefore crucial that they are combined into one overall design that best suits human preferences. Such adaptive design methods only help to support the meaning of the creation, but not the final design itself. It is simply a framework or instrument to accompany a creative expression. However, all authors assume that the patterns are merely hypotheses of possible solutions for certain contexts. They still need to be tested and adapted several times in reality.

From the identification of the published critiques we can conclude that it is essential for a designer to gain insight into all three parts of the trilogy as well as all three levels of critiques (from different authors) that have appeared concerning his whole body of work (Alexander, 1977) before one can actually gain a deeper insight into it. When one is aware of some incompleteness within a global theory one can take this into account or perhaps even formulate iterations or changes for it.

In addition, the main purpose of placing patterns within a system or a patterns language structure is to enable designers to follow a logical design process in which the patterns are converted into empirical projects in which all aspects are combined into one high-quality overall design.
The patterns are the building blocks and by placing them in a certain structure we will determine the relationship between the different patterns. Park (2015) and Winn (2014) have tried to classify the relationship between the different patterns in three different ways, first in a very logical way by creating a kind of tree trunk structure of main patterns and their main contributors. Another way is to link a pattern to several other patterns within a global network of patterns or also called a pattern language structure. Lastly different kinds or species of patterns can be grouped together. This is in order to maintain an overview of the complex pattern language structure and to choose the right solution strategy when a specific problem occurs. In short, communicating very transparently why certain choices where made during the design process, within a system of patterns, is a lot more valuable than trying to create a generic solution with a universal logic. The result is a constant balancing act between the universality and keeping the flexibility.

Mastering both the analysis of the existing theories, the identification of the published critiques and the classification of the knowledge of patterns (languages) can be a very useful medium to formulate the best possible solution for almost every complex design task with the corresponding context. This requires a deeper understanding of his whole body of work and a clear categorisation to enable the interpretation of the pattern language structure. This in order to be able to make effective use of it as a future architect by adapting and using existing related patterns or by developing a new pattern language with the knowledge gained from the analysis and with the critiques in mind.

In the previous chapter we saw that almost all of the discussed patterns focus on an urban or built environment. Only exceptionally natural infrastructures are taken into account, e.g. paths/rivers (Lynch, 1960). In the following chapter parametricism will be thoroughly researched, as a next step to be able to design with these identified patterns of nature. How can we convert them into architectural concepts and which tools we can use to experiment with this to quickly test a variety of functions?

INTRODUCTION PARAMETRIC DESIGN

The previous chapter on pattern(languages) is something that already drove a major conceptual change within the practice of architecture. This systematic way of thinking of Christopher Alexander, Kevin Lynch, John Habraken and Jane Jacobs, among others, was truly innovative. In order to start working with a certain system as a designer, and moreover, to allow others to participate in this or get started with it, we have to look for methodologies. As we said, we were more interested in the graphical way of using patterns and in the data visualization of systems as a way to start working with those patterns (Alexander, 1977; Lynch, 1960). Parametric design is an area that explored this.

Subsequently, the development of new design programs and other design tools such as Revit, Rhino and Grasshopper, together with new theories from Cedric Price, Zaha Hadid and Patrick Schumacher contributed to the development of parametric design. Many advantages were associated with this, namely the rapid testing of various similar options, supporting organic shaped design. However, together with these advantages and the development of a new, unseen design language, there are of course several challenges and disadvantages. Do these programs change the role of the architect? How are these flowing shapes converted into an effective building or how can we translate them on a structural level? Moreover, it is not always easy to describe or measure a certain organic shape as it does not really have measured sides or corners.

This chapter discusses how parametric design can be the next step in this systematic way of thinking about these pattern(languages). First the existing theory is methodically analysed, then the various published critiques and (dis)advantages are identified and finally a deeper insight into this design method is classified.

Research into parametric design methods is crucial in order to be able to experiment and subsequently design appropriate solutions with the identified natural patterns. What are the different methods to deal with such design challenges? How to tackle these, what to pay attention to during the design process. Is this something one can do with the use of technology, maybe using support programs or can it be done without these tools and is it rather a way of thinking that one uses? And what exactly are the pros and cons when you choose to use this parametric design method during the design process? All these emerging questions will be addressed in the following chapter.

PARAMETRIC DESIGN

1. ANALYSIS THEORY

In this analysis of the existing theory the main concept of parametric design will be discussed first. Subsequently, some key authors will be studied thoroughly. Each with their own way of approaching this conceptual method for form generation, using design patterns. Cedric Price focussing on interaction between architecture human and nature, Zaha Hadid using it sculpturally, Schumacher approaching it more philosophically and lastly Bernstein and Rutten using it generically.

1.1. INTRODUCTION PARAMETRICISM

The term parametricism refers to a new approach of architectural design all based upon the concept of parameters, namely parametric design. It defines relations between design elements, utilising parameters, to set up a range of formal alternatives. It relies on algorithms, programs and computers to manipulate these parametric equations for design purposes. This implies that all elements of the design become parametrically variable and mutually adaptive. This creates great opportunities for architects to optimize their design process, but this also comes with some challenges. For instance, when a beautiful, fluid shape is defined, it is really easy to test out several variations, but sometimes it can be quite challenging to find appropriate constructional solutions for this specific shape. Besides using complex algorithms for parametric design, research shows that it can also be undertaken without the use of computer programs (Zarei, 2012).

1.2. A CONCEPTUAL METHOD FOR FORM GENERATION

Even though parametricism provides an efficient conceptual method for form generation and testing design principles, parametric design can hardly be recognized as a new architectural style, among the mainstream architectural practices (Zarei, 2012). They are often to focused on all the challenges these parametric design methods can bring with them. Among students this often is more popular, they like to use software such as Grasshopper and Rhino. But the design tasks given to them are merely made up to practice the designing skill itself, and are therefore no real design situations.

This means that they are often less aware of certain challenges that come with it in a real design situation.

Parametric design is a conceptual method for form generation, which allows designers to quickly experiment with different kinds of design patterns for instance.

Furthermore it is important to explain the difference between CAD, computer aided software, and BIM, building information modelling, for the further development of this research paper.

CAD is nothing more than deploying a computer to assist with the design process/ drawing process. BIM literally refers to creating a comprehensive database for a building (Zarei, 2012), which facilitates the collaboration between the different roles of the entire design team. For instance walls are just drawn as parallel lines in CAD software, but BIM is object-oriented thus uses intelligent building objects.

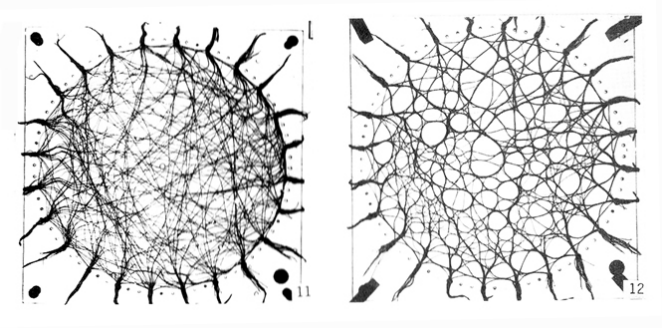


Figure 1.2. Wool-thread model by Marek Kolodziejczyk

This image is from Marek Kolodziejczyk's wool-thread model to compute optimised detour path networks. Depending on the adjustable parameter of the thread's sur-length, the apparatus - through the fusion of threads - generates a solution that significantly reduces the overall length of the path system while maintaining a low average detour factor. This is a good representation of the principles used in a parametric design method.

PARAMETRIC DESIGN

1. ANALYSIS THEORY

1.3. KEY AUTHORS

1.3.1. CEDRIC PRICE - GENERATOR, 1976

A British architect, who interpreted architecture as setting conditions for interaction in contradiction to creating conditions for the more formal will of the designer (Steenson, 2010). The famous statement 'Technology is the answer, but what was the question?' is from him as well (Price, 1976). **He uses this parametric design method very conceptually, to experiment with patterns in order to question the role of the architect in the community as well, thus more as a social experiment.**

With his generator he researched creating conditions for changing personal interactions in a reconfigurable and responsive architectural project. His intention was that this would serve as an activity centre and retreat for a small group of visitors at the White Oak Plantation, situated on the coastal border between Georgia and Florida.

'A building which will not contradict, but enhance the feeling of being in the middle of nowhere; has to be accessible to the public as well as to private guests; it has to create a feeling of seclusion conducive to create impulses, yet... accommodate audiences; has to respect the wilderness of the environment while accommodating a grand piano; has to respect the continuity of the history of the place while being innovative' (Price, 2002).

Cedric Price developed a scheme of 150 mobile cubes constructed with infill panels, glazing and sliding glass doors. He also added board-walks, catwalks and screens. These could be combined by a mobile crane replacing them, according to the wishes of the user or to support any activities they had in mind, whether public or private, serious or banal (Steenson, 2010).

He then arranged several 'Generator-menus', based on a set of programmatic research tools. After asking several potential users of Generator he listed all the activities they might want to do at the White Oak Plantation, such as watching a film, reading, writing poetry, going on a walk, etc. Afterwards they also rated the requirements for these listed activities in terms of space, privacy, quietness and infrastructure.

Lastly he used the simple rules from the 'Three Peg Game'; take turns with the other player in forming a line of three same-coloured pegs, whether vertically, horizontally or diagonally (Steenson, 2010).

Cedric Price wrote in 1976; *' The whole intention of this project is to create an architecture sufficiently responsive to the making of a change of mind constructively pleasurable'*. He sought to create a flexible, reconfigurable kind of architecture that would bring joy to its users (Steenson, 2010).

These technical ideas from Price are only now being realized, but all the groundwork considering its flexible program and designed elements were already there for the Generator. Computers generated unexpected interactions between architecture and the users. This completely shifted the roles of the designers and users, by asking who and what was responsible for this interactive kind of architecture and at the same time it was challenging the very performance of architecture.

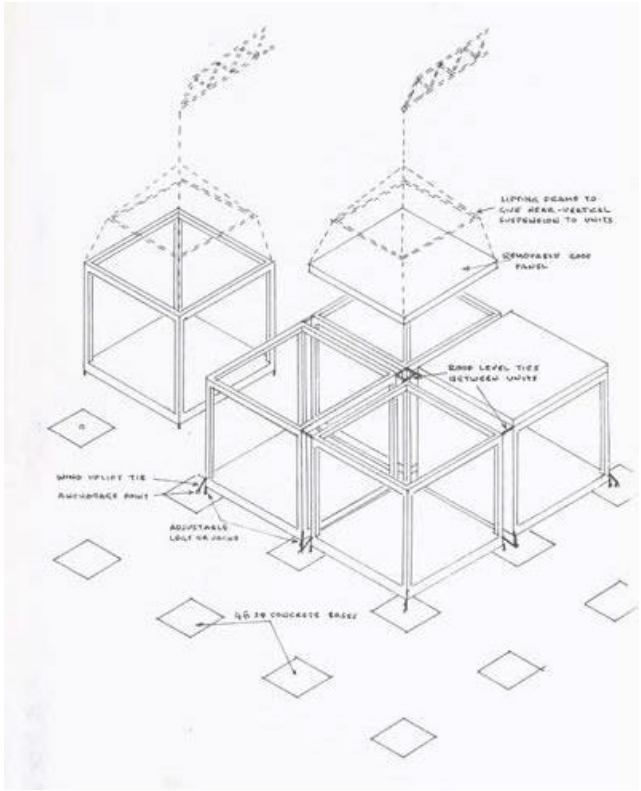


Figure 1.3.1. Generator by Cedric Price

PARAMETRIC DESIGN

1. ANALYSIS THEORY

1.3. KEY AUTHORS

1.3.2. ZAHA HADID - VITRA FIRE STATION, 1993

This building plays an important role in the shift towards the mindset that is needed for parametric design thinking. We can describe this as a formal experiment when using patterns.

It is the first complete Zaha Hadid building ever built and rather than using modernistic and most of the time orthogonal design methods, it is composed of a layered series of breaking and tilting walls, a more sculptural approach of architecture.

It is intended to be the key element within a linear landscaped zone, by artificially extending the linear patterns found in the surroundings. Thus it is designed as a connecting unit rather than as an isolated object; which implies that it is defining space rather than occupying space. The rooms inside also follow this linear organisation. The spaces are arranged in such way that they are only visible from a perpendicular point of view.

The Vitra Fire Station is a sculpture on it's own made out of exposed, reinforced concrete. The almost complete absence of colours and orthogonal angels creates a very special impressive space when visiting this building. The only accent that is present are the bright red fire trucks. Furthermore there are also no edgings or claddings used to retain this simplicity and clarity of this prismatic like volume even more.

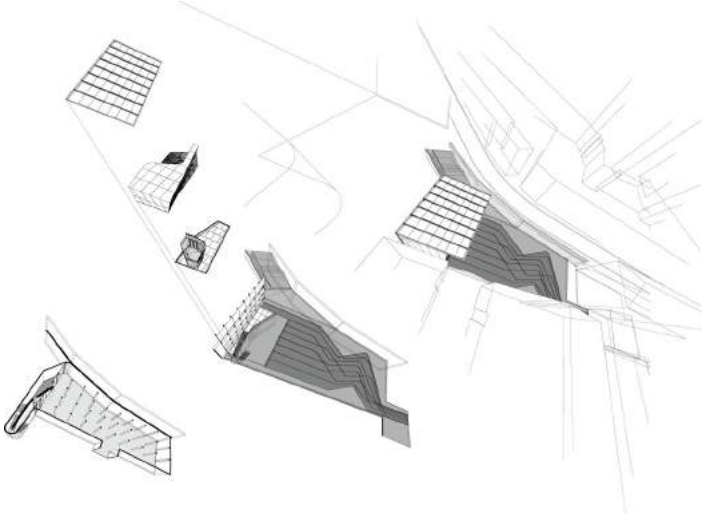


Figure 1.3.2. Vitra Fire Station by Zaha Hadid Architects

PARAMETRIC DESIGN

1. ANALYSIS THEORY

1.4. MAIN INVENTIONS

1.4.1. BERNSTEIN - REVIT, 2000

Figure 1.4.1. Revit Technology Corporation

The Revit Technology Corporation aspired to create 'the first parametric building modeller for architects and building design professionals'. Before Autodesk bought it in 2002, the Revit website even issued a definition of parametric on their welcoming page. **Their interpretation of parametric design is an object based on parametric equations adaptable by the designer for particular circumstances. Thus a more technological experiment within parametric design.** For instance, when turning a roof automatically all plans, sections, elevations, dimensions and schedules are adjusted to the change of the model.

This 'invention' has a huge impact on the design efficiency, it makes it much easier to test out several options for certain building components for instance or to adapt certain things after drawing the building digitally.

Comparing this to ordinary CAD drawing software, consisting of only digital lines drawn one by one, and the fact that the drawings were not linked to each other. When something of the design changed ever single drawing needed to be adapted manually.

1.4.2. D. RUTTEN - GRASSHOPPER, 2007

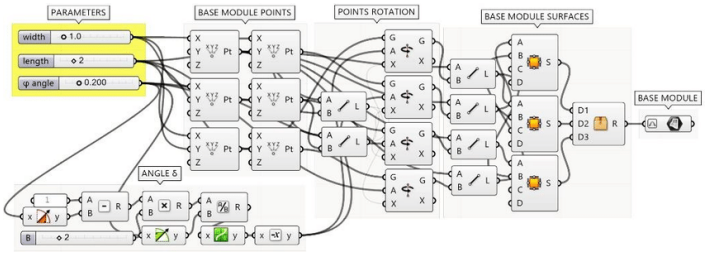


Figure 1.4.2. Grasshopper by D. Rutten

Grasshopper was developed by David Rutten in September 2007 at Robert McNeel & Associates. It is a visual programming language that runs within the Rhinoceros 3D CAD application. When using this software you can create a program by placing components on the canvas. Then the outputs of these components must be connected to the subsequent input of the following components. Afterwards it became a part of the standard tool-set in Rhino.

The advantage of this program, using numerical sliders, is that you can very easily test variations of the same shape and, for example, adjust the size/width/length by sliding with them.
In addition, a set of geometric rules can be set to obtain a seemingly irregular or organic form. Grasshopper can be used by numerous practices for all kinds of scales, e.g. product design, architecture, engineering etc...

PARAMETRIC DESIGN

1. ANALYSIS THEORY

1.5. PHILOSOPHICAL DISCUSSION

1.5.1. P. SCHUMACHER - PARAMETRICISM, A NEW AND GLOBAL STYLE FOR ARCHITECTURE AND URBAN DESIGN

Pursuing the parametric design paradigm all the way, penetrating into all corners of the discipline (Schumacher, 2008). 'Systematic, adaptive variation, continuous differentiation (not only mere variety) and dynamic, parametric figuration concerns all design tasks from urbanism to the level of tectonic detail, interior furnishing and the world of products' (Schumacher, 2008).

Since architecture finds itself in a very important era of continuous innovation, retooling the discipline and adapting both the urban and architectural landscape to social and economic reality is crucial. The former mass society was characterized by a nearly universal consumption standard, but this has changed completely into a very heterogeneous society with multiple individual wishes. So avant-garde architecture and urbanism should correspond to this complexity by organising and articulating it. For this we are in need of a new repertoire, both on the scale of architecture and on an urban scale, to be able to create complex fields which are densely layered and continuously differentiated (Schumacher, 2008). By retooling they mean introducing methods based on parameters, thus parametric design systems.

According to Schumacher, this is the great new style after modernism. Deconstructivism and Postmodernism were only transitional episodes that announced this longer period of research and innovation. We can describe innovation in architecture as pursuing a new style. In history revolutionary periods often triggered the development of a new style of architecture, by gathering the design research efforts into a collective endeavour. Each style can be described as a hard core of principles and a characteristic way of tackling design problems and tasks (Schumacher, 2008). Telling us which paths of research to avoid and which to pursue. This prevents relapsing into old habits or patterns that are not fully consistent with the new core guiding principles and working towards one collective direction.

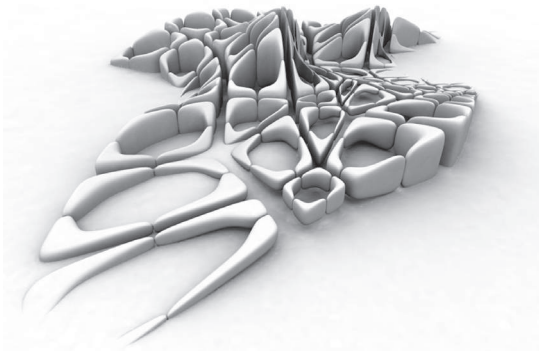


Figure 1.5.1. A new and Global Style for Architecture and Urban Design by P. Schumacher

'Parametricism emerges from the creative exploitation of parametric design systems in view of articulating increasingly complex social processes and institutions' (Schumacher, 2008).

The parametric design tools do not themselves provide this new architectural style, instead the modernist architects that employ them do to absorb this rising complexity. Thus the mindset of the designers. Frequently this sense of organisation resembles to natural systems, where all forms are a result of interacting forces.

The further development of parametricism can be divided into five different agenda's:
The first one is the inter-articulation of sub-systems. With this they mean moving from a single system differentiation to the script. For instance from separate facade components into one building envelope.

Secondly, parametric accentuation; with this they mean the ambition to enhance the overall sense of organic integration through intricate correlations that favour deviation amplification rather than compensatory or ameliorating adaptations (Schumacher, 2008). For instance when generative components are placed onto a curved surface that they are modificated to amplify this curve.

Next, parametric figuration; meaning very complex parametric configurations, of which changing the parameters can lead to serious change. For this it is necessary that, besides the geometrical object parameters, there are variable parameters representing the surrounding added.

Furthermore they expect parametric responsiveness; so that environments can be designed with a built-in kinetic capacity to change itself to the current surrounding (use-patterns and real time occupation).

Lastly, parametric urbanism in which the swarm of changing buildings results in a changing/ adapting urban fabric.

PARAMETRIC DESIGN

1. ANALYSIS THEORY

1.6. CONCLUSION ANALYSIS

From the previous analysis of the theory we can conclude that the term parametricism refers to a new approach to architectural design. In which one uses parameters to test formal alternatives in a fast way (Zarei, 2012). This of course creates a lot of possibilities for an architect during the design process, because one can very quickly test thousands of variations of a certain shape without too much effort. In addition, we must always make sure that we do not lose our sense of reality, the form we create must of course also be constructively feasible afterwards.

In spite of this efficient and conceptual method of generating and testing forms, we cannot recognize parametricism as a new architectural style, within everyday architectural practices. Contrary to the free-thinking students, these often occupy themselves too much with all its negative points.

Furthermore, Cedric Price had already laid the foundations for this conceptual thinking with his Generator (1976), in which he looked for conditions to convert changing personal interaction into responsive and reconfigurable architecture.

One of the most influential buildings within parametric design/thinking was the Vitra Fire Station designed by Zaha Hadid Architects (1993). Architecture was seen more as a sculpture in its own right, emerging from a combination of shapes/surfaces.

In addition, the rise of this parametricism is of course due to the development of new technologies/software under which Revit and Grasshopper played an enormously important role.

Schumacher was also very influential in the development of what he considered to be a new global style for architecture and urban design. According to him, architecture is at a very important moment of constant innovation. For this reason it is very important to retool our discipline and adapt it to social and economic reality (Schumacher, 2008).

In short, it is a very promising discipline which is developing more and more in recent years, this extra dimension increases the architectural freedom and allows very fast adjustments or testing when using design patterns.

This conceptual method for form generation, using patterns, can be used merely as a mindset or conceptually (Price,1976) for a social experiment, more sculpturally or as a formal experiment (Hadid, 1993) or lastly more generically as a technological experiment (Bernstein, 2000; Rutten, 2007). This experimenting on these three levels when designing with design patterns as an architect is extremely useful and is something I will include in my own master project as well. Especially the sculptural and social experiment. I tried to experiment with the technological aspect as well but due to a lack of time I had to prioritise, in order to identify the different natural patterns in order to turn this is a logic and valuable design proposal. I will further experiment and research on this technological aspect in my future career as an architect/ designer.

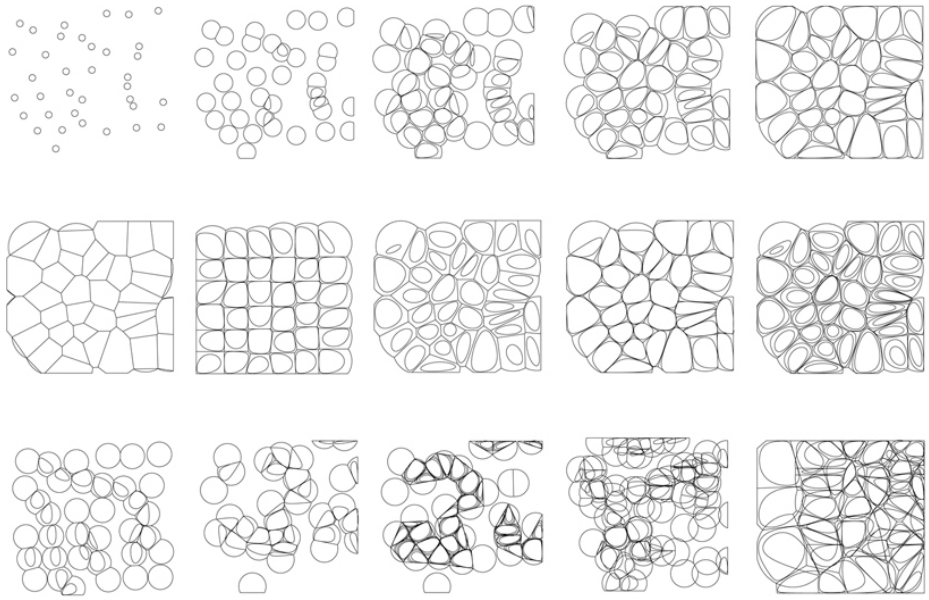


Figure 1.6. Schematic representation of Parametric Design

PARAMETRIC DESIGN

2. IDENTIFICATION CRITIQUES

Next we will discuss the challenges of parametric design in architecture today, this includes the roles in the process and if it's a style or a set of techniques. Furthermore the (dis)advantages of parametricism will be explained.

2.1. CHALLENGES OF PARAMETRIC DESIGN IN ARCHITECTURE TODAY

2.1.1. MAPPING THE ROLES IN THE PROCESS OF PARAMETRIC DESIGN

To begin with, we can distinguish two definitions of the design activity, namely the design as a representation and the design as a computation (Zarei, 2012). Does parametric design changes something about the role of the designer or the role of computer software? We can identify two sorts of designers and their relationship to their tools, first we have the tool-users. They emphasize that design is still the act of representation or embodying ideas that are created in a architects' mind. The second group are the tool-makers. They see design as a sort of calculation. As in many disciplines, the current trend is generally in the middle between the two previous approaches. Some architects are more innovative and may be able to develop a tool themselves than other, rather conservative architects, who continue to use the same familiar techniques for years.

When do we call someone a parametric designer? Is this just when a designer employs parametric software or is it when one fundamentally thinks in parameters when designing (even without the aid of software, or a supporting algorithm) (Zarei, 2012). In the past architects have used a sort of 'natural computation' to produce forms which would now be called parametric, e.g. the Sagrada Familia by Gaudi.

For years, sketching was seen as the method of developing ideas and discussing concepts with each other. Despite the fact that this can now also be done using computer-aided software, sketching and making architectural models remains of enormous importance. In addition, it is also a very understandable communication medium of the architect, this spectrum of communication methods is only extended with other possibilities to communicate his/her ideas such as renders, computer diagrams etc.

We can conclude that the design activity is still based on the way that an architect interprets the client's wishes and needs and how they personally develop a design solution for this (Zarei, 2012). The possibility of using parametric programs cannot change the nature of the design process, it is merely an extension of the possibilities to manipulate or generate forms.

2.1.2. IS IT A STYLE OR A SET OF TECHNIQUES?

In order to answer this much recurring question, we need to examine both the roots of parametric design and its contemporary tendency. Next, we can divide parametric design into two types: parametricism as a new style and parametric design as an extension of similar techniques (Zarei, 2012).

Assuming that this is seen as a new style, it should be possible to link clear principles and a recurring methodology to it, which is not the case. Attempting to do so in an incomplete way could lead to 'incompleteness', and consequently to some architects being named to this style, even though this may not have been their intention (Zarei, 2012).

In addition, one can also design parametric without using parametric software as mentioned in the previous paragraph. So restricting this to when an architect uses parametric software is very short-sighted, because one can also use parametric software to design a modernist aesthetics (e.g. Norman Foster) and vice versa.

According to P. Schumacher, these parametric tools cannot start a new style themselves, they require a designer who has the knowledge of programming and scriptwriting. Since this is a methodology that one has to possess as an architect before one can design it this way, we can call it a style. On the other hand, it is sometimes only used to solve constructive problems or manufacturing issues during the design process, or to process data. This can be considered as a set of techniques to be used.

Figure 2.1.2. A style or a set of techniques?

PARAMETRIC DESIGN

2. IDENTIFICATION CRITIQUES

2.1. CHALLENGES OF PARAMETRIC DESIGN IN ARCHITECTURE TODAY

Although the possibilities of quickly manipulating/generating shapes, for example, are clear from research into parametric design, these benefits of the discipline, or how best to name it, are also accompanied by various challenges today. In my opinion, the greatest challenge is the complexity, as a designer one has to master this medium quite well before one can effectively design something valuable with it.

Once one can work with such programs, and has the programming and scripting under control, this opens up a new design methodology. Consequently, this could also result in a broadening of possibilities during the design process. One should not necessarily make use of this, but if it is necessary to process data, parametrize organic shapes or solve constructive problems this can often be a great aid.

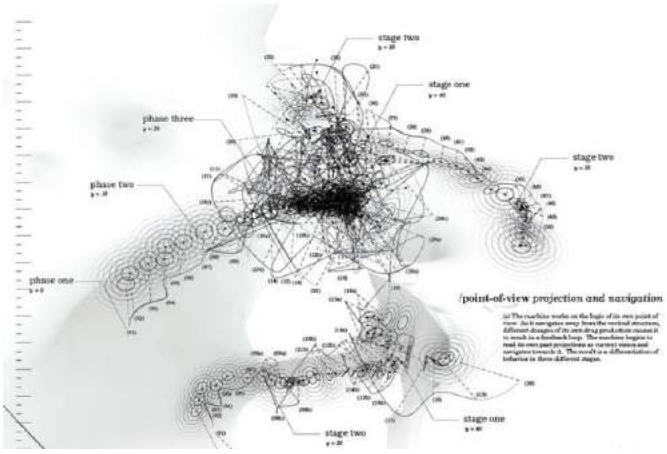


Figure 2.1. Challenges of Parametric design in Architecture today?

In addition, there remains the argument whether this is 'better' than a design one has generated without using these algorithms. Where exactly is this boundary between being extremely useful or rather an obstacle as an architect? This is therefore a very important consideration that one must constantly make as a designer or architect. Ideas should emerge from interpreting the wishes and needs of the client or society, how these are developed can be done in several ways, with or without the use of different techniques and/or computer-aided programs.

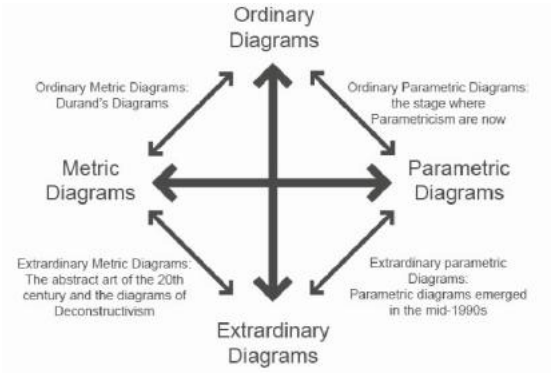


Figure 2.2. Ordinary vs. Extraordinary Diagrams, Metric vs. Parametric Diagrams

2.2. (DIS)ADVANTAGES OF PARAMETRICISM

2.2.1. FACILITATES ORGANIC SHAPED DESIGN

Parametric software is mainly used to facilitate creating organic shaped volumes, shapes, etc.. An example of another interesting function within this parametric software is the application of a certain pattern on an undulating surface, for example for façade designs. In addition, one can also use effective data from the environment to start designing or to generate interaction with its users.

2.2.2. ALLOWS RAPID TESTING OF PARAMETRIC VARIETIES

As mentioned before, the biggest advantage of a parametrized form is that you can very easily generate organic forms and then very quickly modify or transform them. The same shape can, depending on which parameters you used to generate it, immediately be modified or stretched in width or height, for instance.

2.2.3. CONSTRUCTION DIFFICULTIES

When designing parametrically, we should always keep in mind that the shapes we are creating have to be build or translated into real constructional parts. Sometimes crazy design ideas can result in difficulties with the construction of it. Nowadays a lot of new materials and techniques exist for this, but we do have to keep reality in mind when designing.

2.2.4. THE DEPENDENCY OF DESIGNED FORMS ON SOFTWARE

Moreover, it is quite difficult to dimension a plan of an organic form, in contrast to orthogonal forms where it is always clear from one side to the other. There really is no beginning or end. Only when its origin lies in primary forms, e.g. a composition of circles or arcs, it makes this a bit easier. Otherwise it often is a rather emotional or aesthetic form that has to be measured afterwards. This can make it difficult for the communication and coordination of both the design and construction process.

PARAMETRIC DESIGN

2. IDENTIFICATION CRITIQUES

2.3. CONCLUSION IDENTIFICATION

From the previous critiques we can therefore conclude that there are two different definitions to define the activity of design, namely design as representation and design as a computation (Zarei, 2012). These are called (rather conservative) tool-users or (rather innovative) tool-makers, respectively. As with many disciplines, the current trend is somewhere in the middle between the two.

Next, parametric design really means using a parametric methodology, this can be done with or without the help of software. So one is not necessarily a parametric designer when one simply uses parametric software, the fundamental way of thinking must be there (Schumacher, 2008).

Besides this, sketching and making architectural models remains a very important communication medium, it is only complemented by other technological possibilities, but certainly not suppressed.

One can only call parametricism a new style when one actually possesses the knowledge of programming and scriptwriting and starts from this to design. When this is only used as a data processing tool, for example, we consider it as a set of techniques that can be used (Schumacher, 2008).

Despite the many possibilities that parametric design offers (facilitates organic shaped design and allows rapid testing of parametric varieties), it also involves many difficulties (construction difficulties and dependency of designed forms on software). Of which the main challenge is its complexity, both to learn it and to be able to use it effectively during the design process.

Finally, as an architect, one should always question his techniques and tools whether they are effectively suited to elaborate his vision, and in what combination and in what order they should be used (Figure 2.3.).

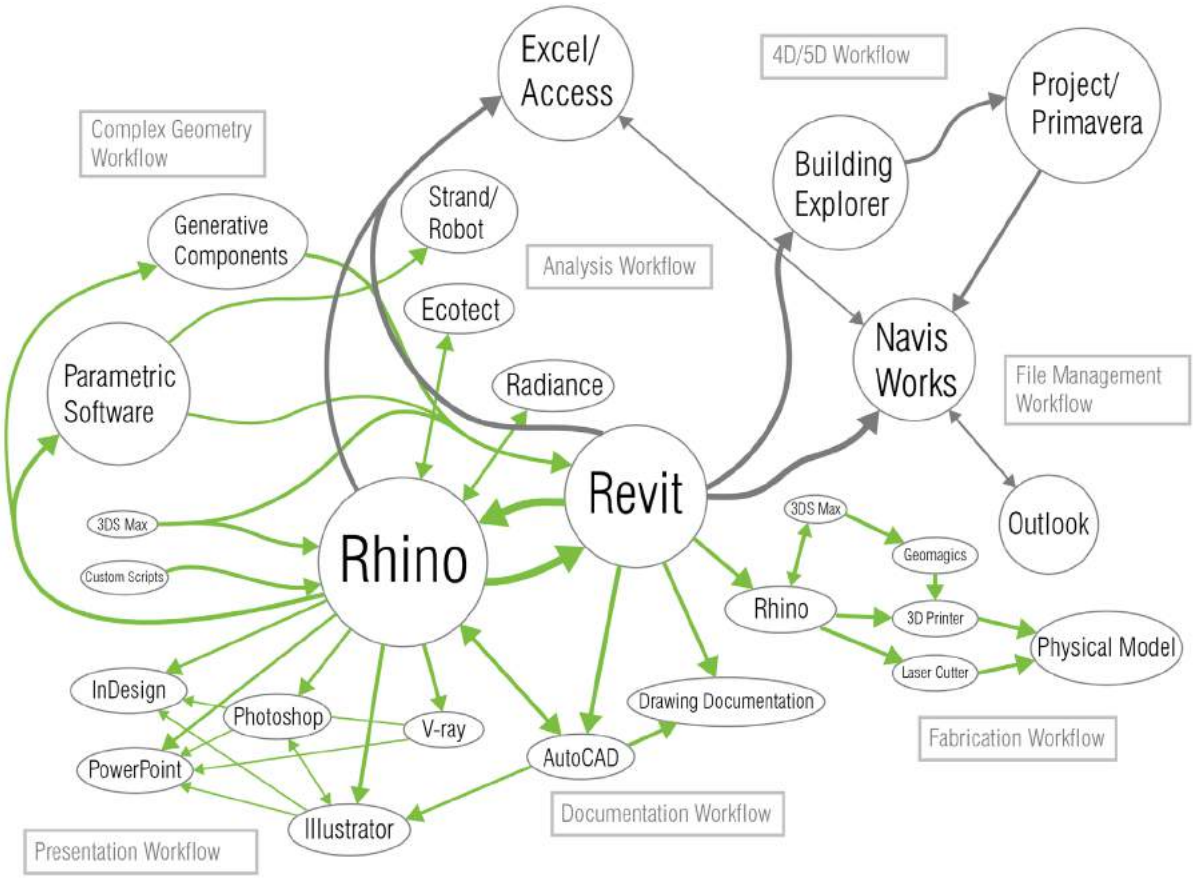


Figure 2.3. Workflow Different Parametric Design Tools

PARAMETRIC DESIGN

3. CLASSIFICATION KNOWLEDGE

In this classification of the knowledge, we will discuss how this mindset of parametric design can be used, from a designing trough research point of perspective, and when using design patterns. Furthermore, the things we have to be careful with as a designer when using this mindset will be clarified.

3.1. MULTIPLE POSSIBILITIES AND ADAPTIVE DESIGN

When one has mastered this theoretical knowledge of programming, thinking in parameters and writing scripts, the possibilities are endless. When you see the diversity between the projects developed within AADRL - Architectural Association Design Research Laboratory each year. They use parametric tools and scripting to develop adaptive and completed architecture programs (Leach, 2009).

The shapes made within this program can be manipulated to obtain thousands of other new designs, this is due to the malleability factor of the shape, which can be adjusted using parametric software until one is satisfied with the result (Futugawa, 2010). This process is also called the form-finding process (Yuan and Yi, 2012).

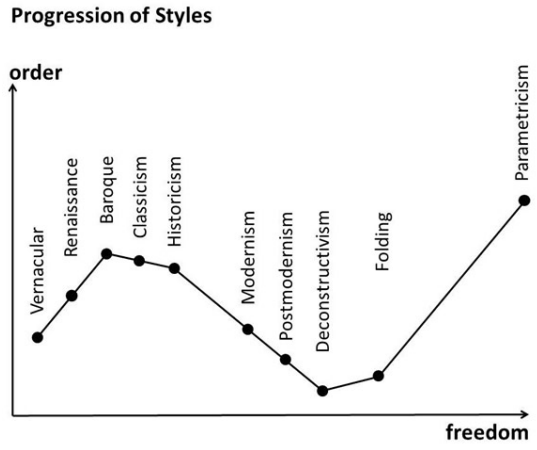


Figure 3.1. Progression of Styles

3.2. ICONIC VERSUS HUMAN ARCHITECTURE

What we must always be careful of when designing (whether parametric or not), is that we continue to design on a human scale and not just design an iconic form that has no meaning in the environment.

The main task of an architect remains to provide an answer to the people and needs of the future users/society. It is in fact sometimes the case that some projects that win the prize of best architectural project also create the most deadly environment around them. On the other hand, there are also iconic buildings that bring the city together and play an important role in society (e.g. Sydney Opera House by Jorn Utzon).

3.3. EXPECTATIONS OF PERPETUAL NOVELTY

Moreover, one continues to expect radically innovative concepts as there are so many possibilities within this discipline of parametric design or what we call best. Of course there are millions of options, but in recent years a lot of them have been generated by students or architects.

But in reality we have to conclude that it is not always possible to arrive at a completely innovative concept, often it is a combination and articulation of various other ways of thinking or projects. As with patterns (languages), these need to be adapted to the local context and the needs and wishes of future users.

3.4. CONCLUSION CLASSIFICATION

We can conclude from the previous paragraphs that if one masters the complex theory of parametric design, there are thousands of possibilities to come to an adaptive design. This is because the programmed shapes are extremely user-friendly to knead or manipulate, which means that an enormous number of variations can result from one form or another.

Although it seems obvious that as a designer one can come up with millions of new shapes, reality sometimes proves the opposite. Many projects are often a combination, articulation or manipulation of pre-existing concepts / ways of thinking of a previous architect.

When creating such shapes we must always be careful not to lose sight of human needs, wishes and scale as an architect when using the digital/ parametric medium. This remains the main task of the architect to provide the best possible answer.

CONCLUSION PARAMETRICISM

We can conclude from the previous chapter that the term parametricism refers to a new architectural approach in which everything is based on the concept of parameters. By defining relationships between these design elements, one can obtain a range of formal alternatives. By using these parameters, the designer can very easily adapt or modify the shape until the desired result is obtained. The development of new technologies/software played a very important role in this. Especially Revit and Grasshopper were important for the further development of parametric design. In addition, the Vitra Fire Station and other projects by Zaha Hadid Architects were also very influential in its further development. P. Schumacher in particular played a tremendously important role in its further development and the philosophical discussion about whether it is a style or a set of techniques..

In spite of this efficient and conceptual method of generating and testing forms, we cannot recognize parametricism as a new architectural style, within everyday architectural practices. It can only be called a style when one effectively uses a parametric methodology (Schumacher, 2008). This can be done in combination with parametric tools or also without using computers (e.g. Sagrada Familia - Gaudi). The basis of this thinking had already been laid much earlier by Cedric Price with The Generator (1976).

In addition to the many possibilities that parametricism offers, we should certainly not lose sight of its challenges. Although one might expect that the role of the architect would change with the advent of new technology, this is not the case (Zarei, 2012). It is merely an extension of the possibilities that can be used during the design process.

When you have this theoretical knowledge and effectively master the parametric methodology, there are numerous possibilities to obtain an adaptive design. However, we must always pay attention during the design process that we design on a human scale and adapt to the wishes and needs of future users. Although one expects perpetual novelty because of these many possibilities, reality sometimes proves the opposite. Just as with patterns (languages), systematic approaches or concepts are adapted, combined and transformed into new ideas.

Mastering both the analysis of the existing theories, the identification of the critiques and the classification of the knowledge of parametricism or parametric design can be a very useful medium to broaden our possibilities as an architect during the design process. This requires a deeper understanding of the global methodology and knowledge of programming and scripting to be able to use these parametric tools in an effective way. When using such systematic approaches or techniques, we must always keep our main task as an architect in mind, namely to provide an answer to the constantly changing demands of society. It is a constant balancing act between the specific and the generic.

We can conclude that this parametric way of thinking is ideal to experiment with the relationship between natural parameters and architectural parameters. Moreover, there are even different parametric design tools available that can facilitate this experiment, which extends our possibilities enormously. Furthermore within this parametricism there are still different methods possible; for example, one can rather sculpturally approach each building on its own as a formal experiment (Hadid, 1993) or focus on the interaction between human, architecture and nature as a social experiment (Price, 1976) or deal with it in a very generative way more as a technological experiment (Grasshopper, 2007).

INTRODUCTION ARCHITECTURAL INTELLIGENCE

After the development of new concepts and design tools, which supported the development of parametric design, the technology of course did not stop evolving over the last few years. New plug-ins for Grasshopper were created all the time, which broadened the possibilities again. Designs could be generated by the computer itself by writing specific algorithms. Designers figured out countless ways of how to use these tools in support of their design (process).

Although many sectors are already using automation, artificial intelligence, deep learning, neural networks and so on, architecture is the only sector that is still lagging behind (Retsin, 2019). After the development of modernism and the discovery of concrete as a new building material, the innovations have been relatively small. This makes it enormously interesting to philosophize/reflect/investigate how we can achieve a more automated/digitalized architecture, not compromising on the quality of it. The possibilities linked to this are endless. Robots that automate our entire building process, from the prefabrication of the various individual parts to the complete assembly or real construction. The computer who generates thousands of design options, after imposing various constraints, to finally evaluate a small number of the best options.

The advantage of architectural intelligence is that the computer actually becomes smarter the more you analyse something several times and convert it into data. This happening at an incredible speed, which we, as humans, cannot keep up with. In my opinion we as architects should not see AI as an impediment to our design possibilities but rather as a broadening of the possibilities and the optimisation/automation of some tasks within the design process.

Of course, there are always a lot of social and economic aspects to these developments that we as architects have to think about thoroughly. The impact on our society and our daily lives can be enormous. From fully automated learning platforms to the reinvention of construction and architectural industry as we know it today, to professions that are being replaced by robots that can do the work much faster and more accurately.

This chapter will first describe how architects created the digital landscape. Next, some key authors will be discussed again, including Nicholas Negroponte, Molly Wright Steenson, Gilles Retsin and Bruno Latour. Subsequently, the challenges we need to watch out for are discussed in depth, as well as a discourse on relevance of design intelligence. Finally, this is merged into what concrete possibilities this could have in the future and in what steps this could support us as architects.

What could provide another step during parametric experimentation with these natural patterns would be Artificial Intelligence. When technology can help to collect the multitude of data, can learn from it and then experiment with it or help to evaluate the different solutions, the endless possibilities only expand further. This is a more technological intelligence that could be used. The intelligence we will be focussing on in this chapter is specifically about identifying and communicating very transparently and clearly about these design patterns (about human, nature and formal things) in order to create a new form of design intelligence that can be used by other designers.

ARCHITECTURAL INTELLIGENCE

1. ANALYSIS THEORY

First the main concept of Artificial Intelligence, as well as how designers and architects created the digital landscape will be explained. Subsequently, some key authors will be discussed; Negroponte, Steenson, Goodfellow, Benigo, Courville, Retsin and Latour.

1.1. INTRODUCTION ARTIFICIAL INTELLIGENCE

Artificial intelligence tries to simulate human intelligent processes or teach them to machines, especially computer systems. It is therefore a branch of computer technology that helps to develop such intelligent machines and software. This includes expert systems, game playing, neural networks, natural language and robotics. In addition, a few other keywords such as data mining, epistemology, ontology, heuristics and optimization apply (Agarwal, 2013). The latter are also called the branches of artificial intelligence.

It all started when people thought they could dissect and describe human intelligence so perfectly that intelligent processes could be derived from it.

Learning processes could then be derived from this, focusing on the collection of data and then using algorithms (or rules) to perform a specific task step by step.

You also have reasoning processes. The focus here is on choosing the right algorithm for a specific outcome.

Finally, there are also self-correction processes. These require a continuous improvement of algorithms in order to obtain the most accurate result.

Figure1.1. Schematic representation of Artificial Intelligence

ARCHITECTURAL INTELLIGENCE

1. ANALYSIS THEORY

1.2. HOW DESIGNERS AND ARCHITECTS CREATED THE DIGITAL LANDSCAPE

With the increasing importance of information in society, the architect had to carry out more complex design assignments between the 1960s and 1980s than in the past (Steenson, 2010). In response, they began to focus on computers and computer software such as cybernetics and artificial intelligence, and other ways of solving problems with the help of the computer. The three most influential architects who contributed to this innovative way of thinking were Christopher Alexander (born 1936), Nicholas Negroponte (born 1943) and Cedric Price (1934-2003). It was around this important period (1960s - 1980s) that the computer in general was also introduced in architectural companies. Of course, one needs an underlying methodology to use it so that generative systems could be developed within architecture, or so that a certain amount of intelligence could be incorporated into architecture.

In 1960 the design pattern was developed by Christopher Alexander, this seemed a good starting point to think about what a systematic approach or technology could mean within architecture. After that, however, it turned out that few architects made effective use of this theory/method, but in computer science it was very influential. After this parametricism emerged about 50 years later, which is actually in the middle between computer science and architecture. Today we are in a time of digital intelligence, it cannot only solve complex geometric systems on a software level, it can also increase the human intellect by generating architectural meaning (Hu, 2017).

Although many people thought that he wanted to use the computer to quickly generate design solutions, this was rather intended to quickly test options from something he had first devised himself. "At the moment, the computer can, in effect, show us only alternatives which we have already thought of. This is not a limitation in the computer. It is a limitation in our own ability to conceive, abstractly, large domains of significant alternatives" (Alexander, 1965).

Today it remains a recurring argument whether a digital tool can and will be seen as a design component, some even fear that digitization could jeopardize design creation (Hu, 2017). "Those that fear the computer itself are invariably those who regard design as an opportunity for personal expression. The computer is a threat to these people because it draws attention to the fact that most current intuitive design is nothing but an outpouring of personal secrets in elastic form" (Alexander, 1965).

This is something that is still very relevant today, because new tools are constantly being developed to broaden our limits of creativity, but also to better manipulate our own imagination, in other words to increase our human intellect, for example by using parametricism. Nevertheless, it is of great importance that we investigate why our discipline, architecture, compared to other disciplines, we are lagging a bit behind in the digital transformation (Hu, 2017).

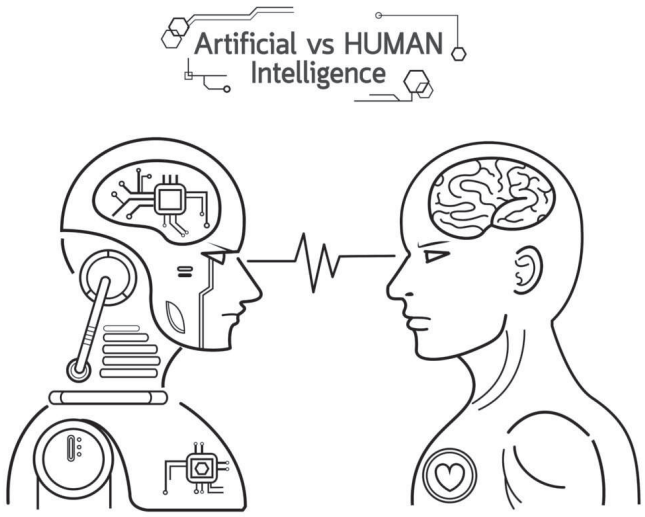


Figure 1.2. Artificial vs. Human Intelligence

ARCHITECTURAL INTELLIGENCE

1. ANALYSIS THEORY

1.3. KEY AUTHORS

1.3.1. NICHOLAS NEGROPONTE, THE ARCHITECTURE MACHINE, TOWARDS A MORE HUMAN ENVIRONMENT, 1970

Nicholas Negroponte (born in 1943) is an American technologist and also an architect, best known by founding the Media Lab of the Massachusetts Institute of Technology, also called MIT. Furthermore, he was an important initiator of the project One Laptop Per Child, or OLPC in short. Furthermore, he taught at several other universities such as Yale, the University of California and Michigan. A year after he started teaching, he founded the MIT Architecture Machine Group, a think tank to stimulate new developments in human-computer interaction.

Contrary to Price, Negroponte, just like Alexander, departed from the idea where the computer was central to the further development of his theory/ methodology. With an 'Architecture Machine' he wanted to strengthen the importance of the computer (Steenson, 2010). It was his goal to develop a symbiotic relationship between architecture and the users/residents. He summarised how this could work in his book 'The Architecture Machine' in 1970. He then complemented this with a second book 'Soft Architecture Machines' in 1975 and of course various programs and computer-controlled design tools that he developed over the years (Steenson, 2010).

The main aim was to transform the design process into a kind of dialogue between machine and man (Steenson, 2010). "The dialogue would be so intimate-even exclusive-that only mutual persuasion and compromise would bring about ideas, unrealisable by either conversant alone. No doubt in such symbiosis it would not be solely the human designer who would decide when the machine is relevant" (Negroponte, 1970). As he pointed out, the decisive role in this process remained with mankind.

According to him, his experiment in 1967, called URBAN 5, failed because the interaction between man and machine was not sophisticated enough and could not adapt to the dialogue that was held. In addition, the work within his 'Architecture Machine Group' further demonstrates the difficulties of effectively developing such generative systems. Like cybernetics and artificial intelligence, the system was intended to observe the user and learn from him in this way, enabling it to respond to a specific moment in time (Steenson, 2010). Unfortunately, at that time the technology had not yet been developed far enough to provide the researchers with sophisticated algorithms and systems.

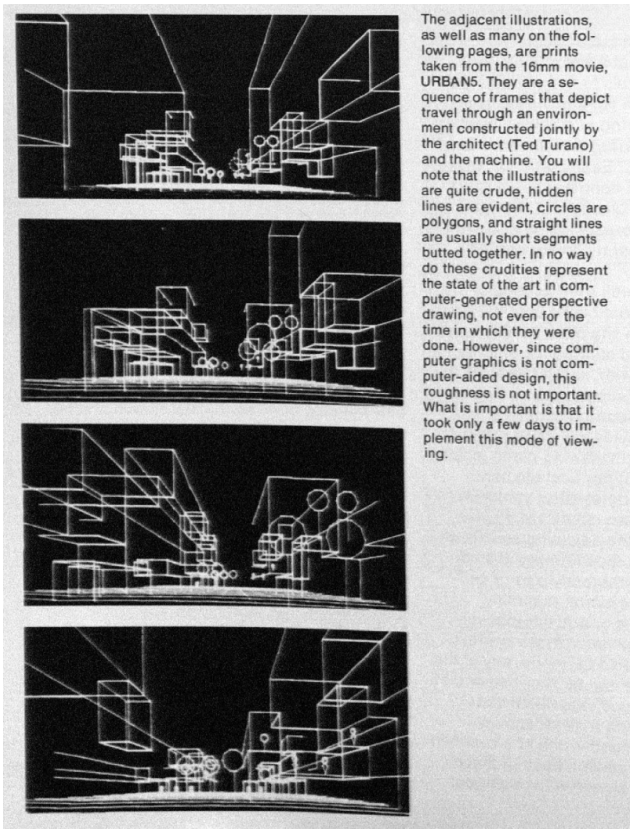


Figure 1.3.1. The Architecture Machine by Nicholas Negroponte

ARCHITECTURAL INTELLIGENCE

1. ANALYSIS THEORY

1.3. KEY AUTHORS

1.3.2. MOLLY WRIGHT STEENSON - ARCHITECTURAL INTELLIGENCE, 2017

Molly Wright Steenson (born 1971), describes herself as a 'designer, writer, speaker and professor who focuses on intersection and implications or design, architecture and artificial intelligence'.

Within this theme of research she wrote her book 'Architectural Intelligence: How Designers and Architects Created the Digital Landscape', published by MIT Press in 2017. This book thoroughly discusses the history of digital design in relation to the history of architecture. She discusses some prominent architects, such as Richard Saul Wurman, Nicholas Negroponte, Christopher Alexander and Cedric Price, and how their methodology has influenced further development. She is also the author of 'Bauhaus Futures', published by MIT Press in 2019. This is about what would keep Bauhaus awake at night, if it were still present today (Steenson, 2019).

1.3.3 GOODFELLOW, BENIGO, COURVILLE - GENERATIVE NEURAL NETWORKS, 2014

Generative Adversarial Networks, also called GANs in short, is a kind of algorithmic architecture that uses two neural networks that complement each other to generate new artificial data that resembles real data. This is something that is already widely used today to generate voices, videos or images (Goodfellow, Benigo, Courville, 2016).

This concept was introduced by Goodfellow, Benigo and Courville in a paper for the University of Montreal in 2014. The possibilities of this concept are infinite, as they can learn to imitate data and spread it. This can of course be used in a positive way or abused in a negative way, ethically speaking. The output of the robots really is very impressive, they even almost look like artists.

What the biggest challenge is within artificial intelligence, is to describe human processes so well that they can be learned and executed by machines or systems. By this we mean intuitive processes that are experienced as very easy or self-evident for humans, such as recognizing faces in a photograph. The book 'Deep Learning' tries to offer a solution to these intuitive problems (Goodfellow, Benigo, Courville, 2016).

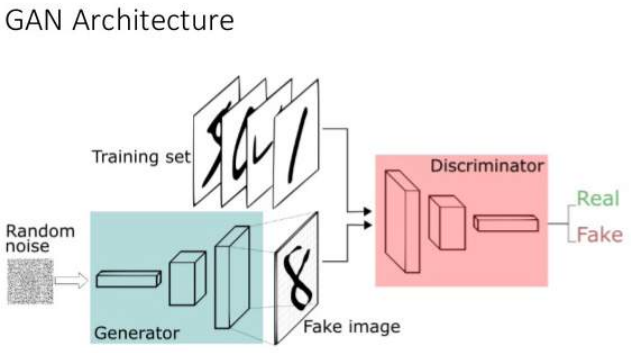


Figure 1.3.3. GAN Architecture by Goodfellow, Benigo, Courville

ARCHITECTURAL INTELLIGENCE

1. ANALYSIS THEORY

1.3. KEY AUTHORS

1.3.4. GILLES RETSIN - DISCRETE ARCHITECTURE, REAPPRAISING THE DIGITAL IN ARCHITECTURE, 2019

Gilles Retsin is a Belgian architect living London who researches what automation could mean in architecture and construction. For this futuristic vision he uses all kinds of technology and robots, he tries to realize his innovative vision in small installations and pushes it with competitions. He recently won a competition of the Architecture Biennale in Talin, Estonia, which is currently built on site.

He has written two books on this theme, the first is Robotic Building: in which he speculates about how we can think about automation and robots as something that has a very deep impact on the world around us. This could, for example, result in a much faster and cheaper building process. He also recently published a second book: Discrete - Reappraising the Digital in Architecture in collaboration with Architectural Design. With this book he wants to inspire young architects and thinkers and inform them what the digital in architecture could mean in the future. After all, the digital has changed everything around us, although architecture is the only sector that has lagged behind (Retsin, 2019).

In the book 'Discrete - Reappraising the Digital in Architecture' he tries to split architecture into all its individual pixels. These elementary particles initially have no function at all, it is only when you put them together that they become functional and, for example, take on the function of floor or supporting column. The implication is that you no longer conceive a building in a traditional way; consisting of floors slabs, walls, load-bearing columns and roofs. They started all over again with this concept in order to obtain a structural system consisting of as few similar particles as possible.

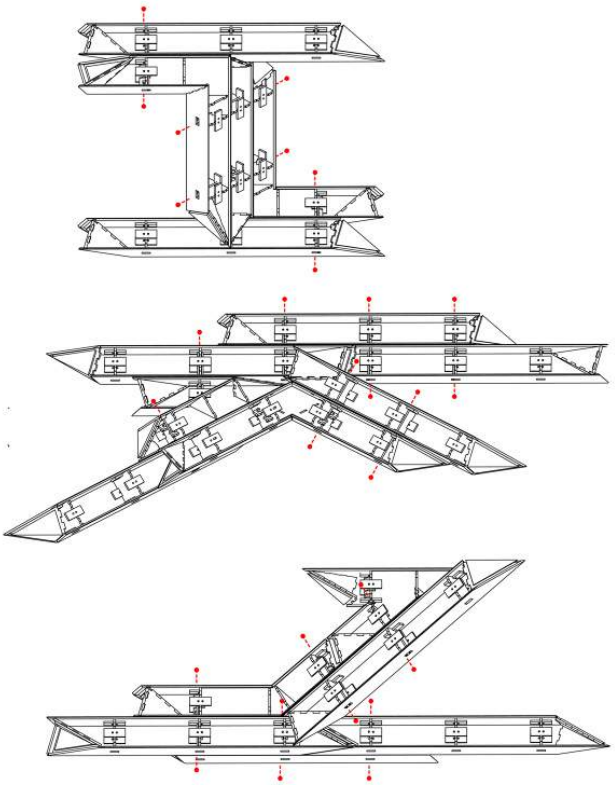


Figure 1.3.4. Discrete architecture by Gilles Retsin

He then designs patterns with these discrete particles and the ways in which they can be joined together or assembled. These patterns are then multiplied into an entire building or pavilion which starts from the same logic or systematic approach. In addition, he also uses generic algorithms and Architectural Intelligence to be able to use the computer as a support during the design process to quickly test many different options or to draw complex structures for him as he envisions them.

What is very interesting about his work is that because he uses the digital within architecture that he needs to think more fundamental as before, stacking granulates or tree trunks back to a primitive hut. A space that is completely conceived by an abstract logic (just like a computer functions), based on male and female connections, still generates many spatial qualities and brings us back to a more primitive way of life.

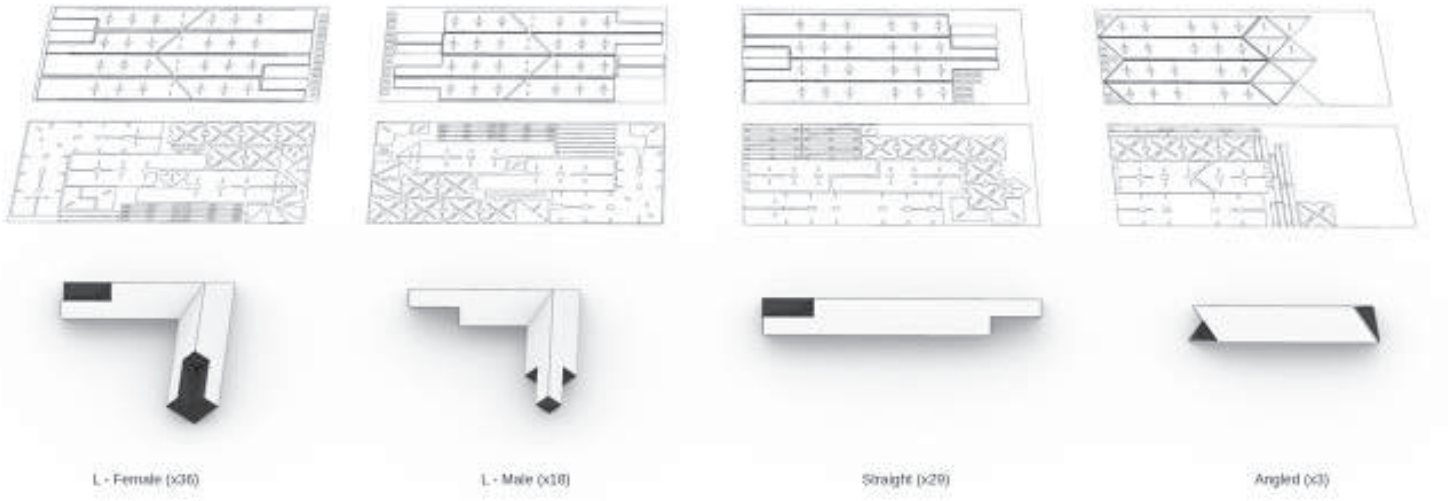


Figure 1.3.4. Example fabrication of pixel building elements

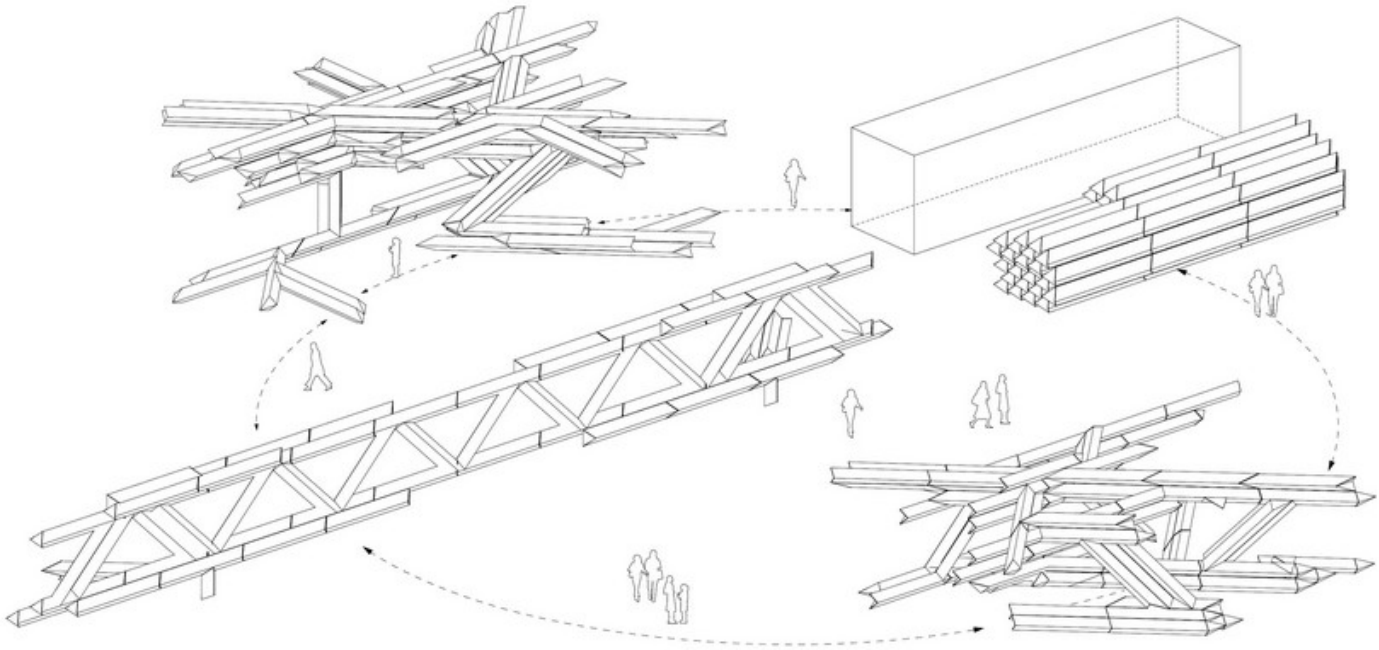


Figure 1.3.4. Example assembly pixel elements on site

ARCHITECTURAL INTELLIGENCE

1. ANALYSIS THEORY

1.3. KEY AUTHORS

1.3.5. BRUNO LATOUR - THE POLITICS OF NATURE, 2004

The French philosopher and sociologist, Bruno Latour is mainly interested in technical sociology as well as scientific sociology. Some of his best-known books are; 'Laboratory Life', 'Science in Action' and 'We were never really Modern'. In fact, we can see him as someone who questions everything that goes on around him. In his relatively recent work 'The Politics of Nature: How to Bring the Sciences Into Democracy' Latour also focuses on political and scientific debates about climate change.

In this epistemological work he considers nature and humans as a hybrid organ instead of separate forms of intelligence. He also states that it is impossible to talk only about nature and politics without talking about science. This is a debate that has occurred several times throughout history. He therefore gives a full explanation of the difficulties of unifying these two into a 'New Collective' and the steps in which this could happen. This Collective should be able to guarantee a return of civil peace, by redefining politics as a progressive composition of a good common world (Latour, 2004).

Today, within the circular economy, there are many 'New Collectives' of landscape projects that try to mediate the nature-human relationship between human well-being and the importance of the environment. The 'New Climatic Regime' clarifies both human and non-human bodies. We do not live in a world where 'passive' nature, with non-humans as inhabitants, is merely in the background of the 'active' culture driven by man. We need to make a shift in orientation and approach both politics and reality in a more inclusive way (Latour, 2004).

Especially with this kind of intelligence I tried to experiment with in the design of my own master project, by making these patterns very tangible and understandable. The next step could be to automatise it.

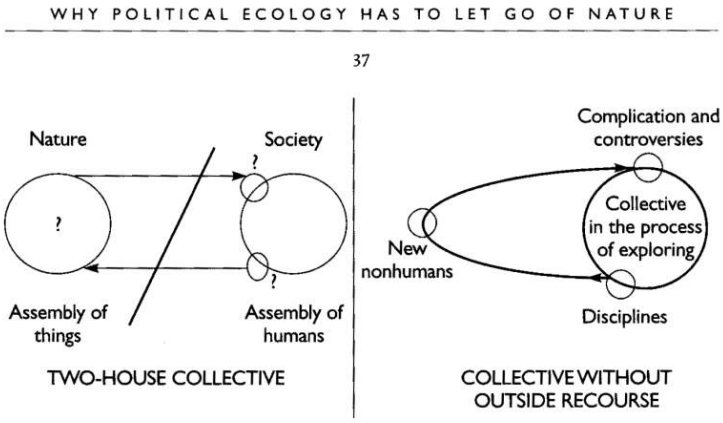


Figure 1.1 The political model with two houses, nature and society, is based on a double split. The model of the collective is based, conversely, on a simple extension of the human and nonhuman members.

Figure 1.3.5. Why political ecology has to let go of nature by Bruno Latour

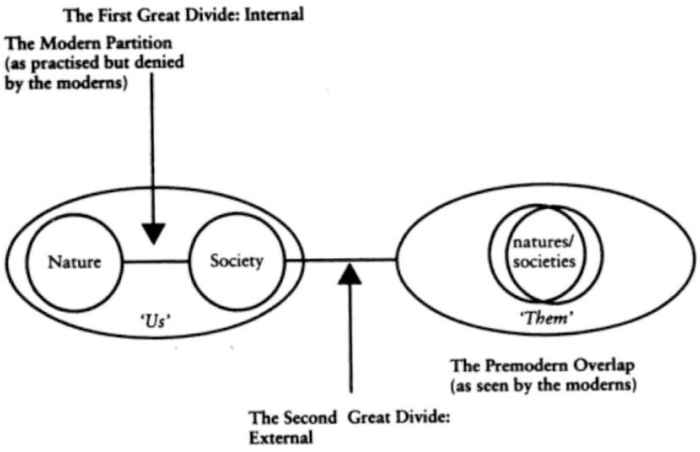


Figure 1.3.5. New Collective between Human and Nature by Bruno Latour

ARCHITECTURAL INTELLIGENCE

1. ANALYSIS THEORY

1.4. CONCLUSION ANALYSIS

From the previous analysis of theory we can conclude that artificial intelligence tries to imitate human intelligent processes and teach them to computer systems. It is very important that we describe these processes as well as possible, this is not always easy as in our case these processes often happen automatically. This is the biggest challenge within architectural intelligence, to describe these human processes as good as possible so they can be learned and executed by machines or robots.

When the complexity of society and the importance of information increased between 1960 and 1980, architects were confronted with more and more complex design issues. As a result, people started experimenting with how computer software or architectural intelligence could support us during the design process. The basis for this was the design pattern, developed by Christopher Alexander in 1960. Subsequently, parametricism developed about 50 years later, which actually stands between computer and architecture. At this moment we are in the middle of experimenting how architectural intelligence, deep learning and cybernetics could support us during the design process. This always after we have formulated an idea or design ourselves as an architect. As already mentioned several times, this is only a way to support us to quickly test options and to be able to derive the best from them, it is absolutely not the intention to have the computers design for us.

For example, Negroponte's aim was to develop a symbiotic relationship between architecture, the user and its inhabitants, which he discussed in 'The Architecture Machine' in 1970. Besides Negroponte the concepts of Molly Wright Steenson were also very innovative, she brought together a lot of insights from different architects in one overview, 'Architectural Intelligence - How Architects created the Digital Landscape'.

Goodfellow, Benigo and Courville also came up with Generative Neural Networks in 2014. This is a kind of algorithm that uses two types of neural networks to generate new artificial data that resemble real data.

Gilles Retsin, is a London-based architect who is exploring the possibilities of automation within architecture. After a lot of research he started designing architecture out of discrete pieces. These are pixel-like elements with each time a male or female connection that can be assembled into a complete structure according to a very cold logic. When they are solely they have no functionality whatsoever, only when they are combined and assembled they fulfil the function of, for example, a wall or floor. This way of thinking is radically innovative and super inspiring for the next generation of architects and designers.

Finally, Bruno Latour presents a new collective between human and nature in his 'Politics of Nature' in 2004. In which these are no longer seen as separate forms of intelligence, but as a fused nature-human intelligence.

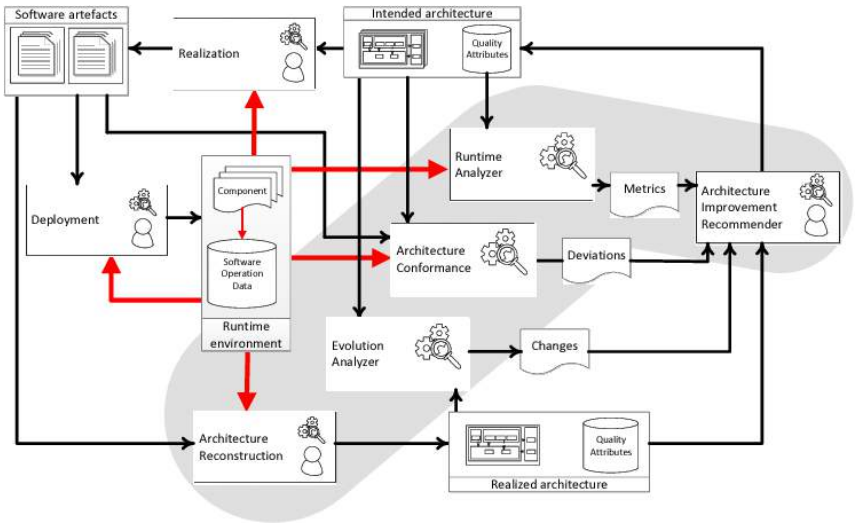


Figure 1.4. Architectural intelligence

ARCHITECTURAL INTELLIGENCE

2. IDENTIFICATION CRITIQUES

The challenges of architectural intelligence as well as a discourse about relevance will be discussed in this identification of critiques.

2.1. CHALLENGES OF ARCHITECTURAL INTELLIGENCE

In addition to the many possibilities that architectural intelligence brings, there are of course a number of challenges for us as architects, urban planners or designers. First and foremost, it is very important to understand the principle and how it works, otherwise it is not possible to make good use of it. Next to that AI works best when there is a lot of data available, this data could be used within seconds enhance the architectural design. Therefore the data must first be available or the information must be converted to meaningful data. This data can then be used to facilitate the selection process of the architect, especially in the early stages of the design.

2.2. A DISCOURSE ABOUT RELEVANCE

2.2.1. RELATIONSHIP BETWEEN ARCHITECTURAL INTELLIGENCE AND ARCHITECTURAL THINKING

What an enormous added value could be, for us as architects, is that when the relationship between architectural intelligence and architectural thinking is as strong as possible. In this way the architect would be able to make use of the innumerable amounts of data during his research and to test a multitude of different ideas in a quick and easy way. Often starting up a project is one of the more difficult phases as an architect, this requires an enormous amount of research, both on the wishes of the client and on construction, design language, context, orientation, functions, urban laws and regulations, etc... Once one has started and is deeper in the project, often it goes faster and faster. Different options can still be tested and weighed against each other but the basis is there.

Moreover, AI can also be used to make the architect's planning process easier, both in terms of construction and budget management. In short, all this data can be used by AI to support our architectural thinking, to facilitate the design process, to speed up the building process and also to obtain a integrated end result.

2.2.2. THE THEORY OF MULTIPLE INTELLIGENCES - HOWARD GARDNER

Gardner's Theory of Multiple Intelligences states that intelligence consists of much more than just the concept of IQ. Intelligence can also be described as a person's intellectual potential, which is something we are born with and which is difficult to change over the years. In his book 'Frames of Mind: The Theory of Multiple Intelligences' he suggests that all people possess different kinds of intelligences. These can be divided into the following eight categories: Visual-Spatial, Linguistic-Verbal, Interpersonal, Intrapersonal, Logical-Mathematical, Musical, Bodily-Kinesthetic, Naturalistic (Gardner, 1993). Of course, each person has their own strengths and weaknesses. When one is aware of these, his/her weaker points could be supported by AI for example.

2.2.3. DESIGN INTELLIGENCE

'Understanding design requires more than just knowing how to design and how to evaluate what has been designed' (Fry, 2005). Design intelligence is something that is difficult to describe. It remains a very complex process in the minds of designers. This design intelligence is something that can only be achieved by someone through a lot of research, practice and rehearsal. The creative process in our heads when designing, is something very difficult to describe exactly and this is something that has been going on for years. Just because we can't describe this very well makes it also very difficult to pass on this knowledge to future generations, students or for example AI software. This proves once again that effective design will always be done by the architect, and is almost impossible to be taken over by machines or robots. They only serve to support us to make it easier, to offer more possibilities, to test and weigh options faster...

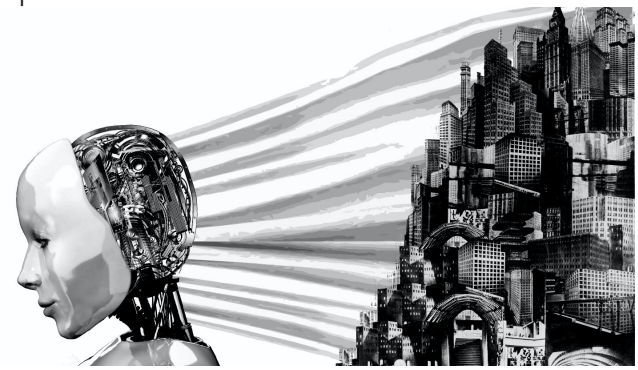


Figure 2.2.3. Design Intelligence

ARCHITECTURAL INTELLIGENCE

2. IDENTIFICATION CRITIQUES

2.4. CONCLUSION IDENTIFICATION

From the previous identification of the critiques about architectural intelligence we can conclude a few things. One of the biggest challenges for architects is that we first have to understand the principle and the way the algorithm works in order to make effective use of it. Once we have mastered this, there are countless possibilities how to make use of this. There only needs to be enough meaningful data available that the algorithm can use.

Furthermore, the greatest added value would be obtained if the architectural intelligence is as close as possible to the architectural thinking of a particular person. When this is the case, the creative brain of the architect could overlap symbiotically with design intelligent machines to co-create designs (Engelbart, 1962). This could result in the facilitation of help during the design process, the quick consideration of different options, a faster building process and above all an integrated end result.

Next, eight different types of intelligences can be distinguished, in stead of only taking into account someone's IQ, namely; Visual-Spatial, Linguistic-Verbal, Interpersonal, Intrapersonal, Logical-Mathematical, Muscial, Bodily-Kinesthethic, Naturalistic (Gardner, 1993).

'Design Intelligence' is a concept that is very difficult to describe, but it mainly is about that 'Understanding design requires more than just knowing how to design and how to evaluate what has been designed' (Fry, 2005).

These criticisms emphasize once again that it is not the intention at all to replace the architect (and his creative design process) by integrating AI systems in architecture, but that these tools could be used merely to facilitate the architect and his own design process.

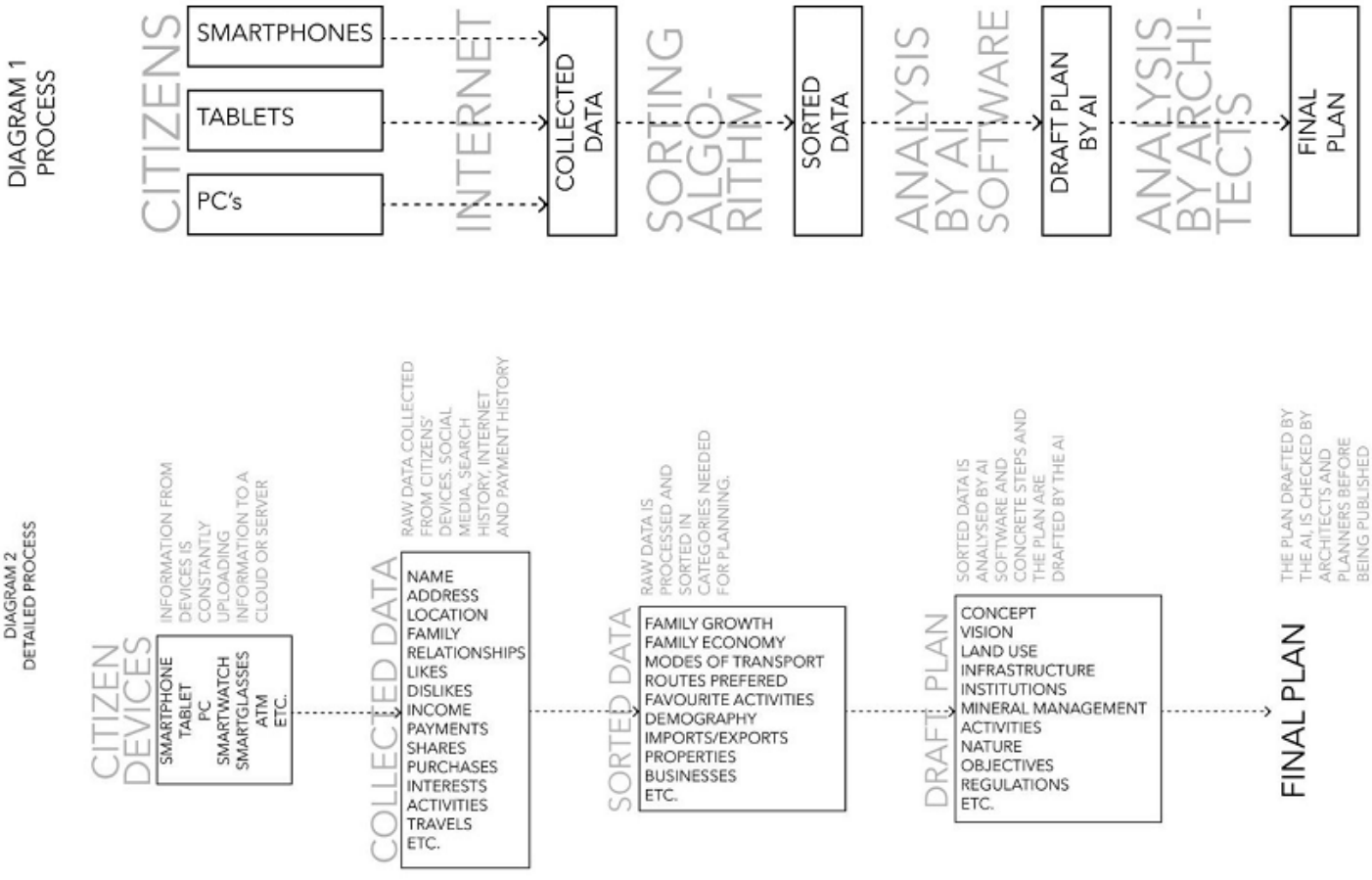


Figure 2.4. Diagrams roughly explaining the process of using AI to draft plans

ARCHITECTURAL INTELLIGENCE

3. CLASSIFICATION KNOWLEDGE

In this classification of knowledge, the possibilities that the technological aspect of artificial intelligence could offer for architecture in the future are discussed as well as some of the techniques that already exist or that are already being experimented with.

3.1. THE ARCHITECTURE OF ARCHITECTURAL INTELLIGENCE

3.1.1. INTRO & SITE

As a designer or architect, the first step before starting designing is to gather as much information as possible to impose some constraints on oneself. Traditionally this started with a visit to the site, some measurements, making sketches and photos. Nowadays it is no longer necessary as an architect to physically go here to collect this information, nowadays one can collect a lot of information from 'The Internet of Things' from his desk. Just think of Google Maps, drone 3D scan, 3D site model using Pix4Dmapper... This allows many architectural firms to realize large projects abroad, which might not have been logistically possible a few years ago.

Moreover, there are already applications, such as Site analysis by depthmapX, that automatically analyse some basic site conditions. This of course speeds up the process of collecting information enormously. What one does with this information is of course up to the architect himself.

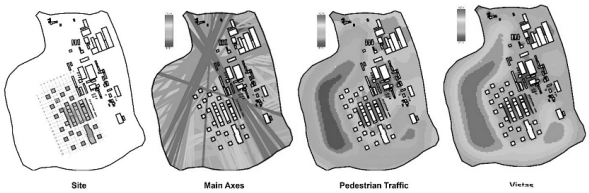


Figure 3.1.1. Intro & Site Analysis by Bartlett University, London

3.1.2. DESIGN DECISION MAKING

The information obtained is then used to make some important choices, which the architect considers important in the project. If one wanted to, one could enter different project parameters, such as the different functions and corresponding surfaces, and then the AI computer system could propose a multitude of solutions that meet these input criteria. In addition, the algorithm can also simulate structural rules derived from nature.

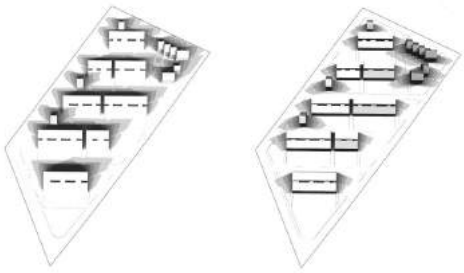


Figure 3.1.2. Design Decision Making

This is of course a very radical way to use AI in architecture. For example, instead of proposing fully elaborated options, it can also help analyse and then optimize an existing project proposal. For example, the fire exits can be inventoried with the Unity 3D program and the organization of the ground plan can be adjusted based on this.

3.1.3. CLIENT & USER

The possibilities AI offers to produce augmented reality shapes could have a huge impact on the way we observe and present architectural designs. This for architects as well as non-architects. When setting up an augmented Reality Headset, the real world is very realistically imitated in a virtual world. Clients could, for example, walk around virtually in different design proposals and then choose based on their virtual experience. Again, the possibilities are endless; the different types of materials, sounds, types of lighting, different weather conditions, etc...

Furthermore, it is even possible to implement feedback directly into this interactive model, in order to adapt as well as possible to the wishes and needs of future users. For example, Tangible Cityscape from MIT Media Lab, are experimenting with how AI can learn from and respond to human experiences.

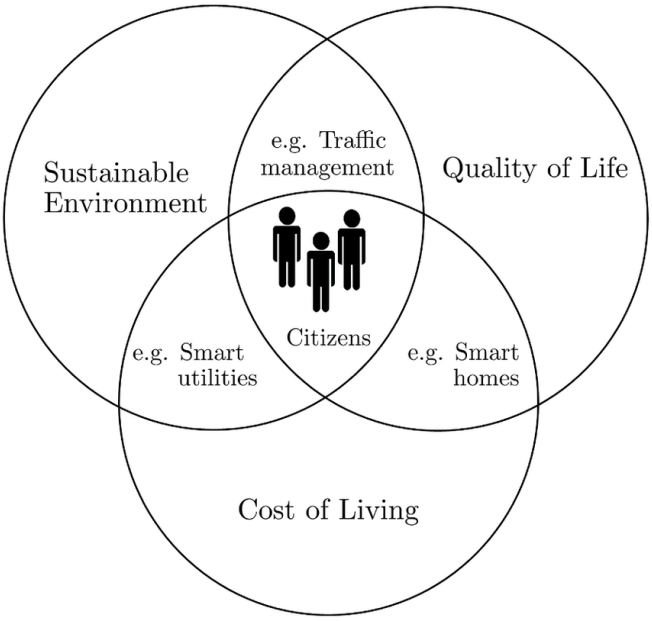


Figure 3.1.3. Client & User

ARCHITECTURAL INTELLIGENCE

3. CLASSIFICATION KNOWLEDGE

3.1. THE ARCHITECTURE OF ARCHITECTURAL INTELLIGENCE

3.1.4. RISE OF ROBOTS CRAFTSMEN

AI is already integrating into the construction sector. This ranges from innovative ways of using known materials in an innovative way to the development of completely new materials with their own properties. *'These new advances in both computation and fabrication let us create an architecture of hitherto unimaginable forms with an unseen level of detail, producing entirely new spatial sensations'*, Michael Hansmeyer, Founder of the Computational Architecture.

Some innovative practices, including Computational Architecture, already use robotic craftsmen instead of traditional craftsmen in their research on AI in fabrication, technology and construction. For example, robots are being developed that could effectively start working on site, but they can also be used to prefabricate certain elements in a very precise way.

Figure 3.1.4. Rise of Robots Craftsmen

3.1.5. INTEGRATING AI SYSTEMS

There are many different researchers and designers working on understanding the potential of computational intelligence within the architecture practice. This in order to improve or even replace some parts of the design process in order to obtain a more functional and user-oriented design.

This may seem very difficult, but architecture and diagramming have been part of complex systems for a long time and have had a significant impact on each other. For example, 'A Pattern Language' by Christopher Alexander has also had an enormous influence on programming.'To think architecturally is to imagine and construct new worlds, integrate systems and organize information' (Alexander, 1964).

3.3. CONCLUSION KNOWLEDGE

From the previous classification of knowledge it became clear that AI in architecture still has a very great potential in all kinds of aspects and in all kinds of stages of the design process or even the entire construction process.

'AI systems will enable architects to utilize the computer as a true partner in solving hard design problems, rather than a super-powerful 3D drafting board' according to Michael Bergin, Principal Research Scientist at Autodesk.

At the beginning of a project it can help to gather as much information as possible about the site and to analyse certain aspects without even having to actually visit it. In addition, it can also be a great help in making design decisions, e.g. by having various solar studies carried out and then letting the architect choose the best options. It is even possible to give certain project inputs and let an algorithm generate design options within these constraints. It is then up to the architect to choose the best outcome and to continue on working on this, but it would be possible that options were generated that the architect had not yet thought of originally. Moreover, people are also experimenting with new construction techniques, innovative materials and even robots craftsmen.

These innovations would not only support the architect during his/her design process, this could also be a great added value for non-professionals. While integrating these AI systems, we try to obtain a more functional, integrated and user-oriented design.

CONCLUSION ARCHITECTURAL INTELLIGENCE

Very briefly described, artificial intelligence tries to simulate and teach human intelligent processes to machines or computer systems. Different processes can be used for this purpose including; learning processes, reasoning processes or self-correction processes.

Designers have been curious for a long time what possibilities technology could offer to support the architect during the design process. Especially during 1960-1980, their interest in this field increased enormously, as the design challenges became more and more complex. The basis of this systematic way of thinking remains the design pattern (Alexander, 1960). Cedric Price and Nicholas Negroponte were also enormously influential in this innovative way of thinking. With 'The Architecture Machine' it was Negroponte's goal to create a symbiotic relationship between architecture and the users or residents.

Today, Molly Wright Steenson is engaged in a great number of research projects related to this theme, such as its origins or other breakthroughs. In addition, many architects are experimenting with all kinds of symbiotic forms of architecture and technology or automation, including Gilles Retsin. His work is even so ground-breaking that he starts thinking about architecture all over again, from the idea of a pixel from which an entire building could then be composed.

Although this often seems self-evident and convenient to be able to use such computer systems or technologies, without any knowledge it is not that easy. If one would like to make use of this as a designer, one must first of course delve a little deeper into how it works exactly, what has already been researched/ experimented with, and so on. Once one has mastered this, however, it is a super useful medium with infinite possibilities.

In this way, it could support the architect in various aspects of the design process, such as site research, design decision making, client & user, construction with robots craft-men or even integrated AI systems. *'AI systems will enable architects to utilize the computer as a true partner in solving hard design problems, rather than a super-powerful 3D drafting board'* according to Michael Bergin, Principal Research Scientist at Autodesk.

What we can conclude from the previous chapter is that there are still enormous possibilities within the field of architecture to work with technology, automation and AI. We are one of the only disciplines that are a bit lagging a bit behind in this digital transformation even (Hu, 2017). For this reason, it is extremely important to continue to examine existing theories on this subject and then classify this knowledge in order to be able to explore with it, as well as not to lose sight of the various challenges involved.

Artificial intelligence is in fact very useful within the parametric design experiment with natural patterns, for different aspects and parts of the design process. It is within reach of every architect today, one merely has to learn it. Moreover, Bruno Latour even proposes a new form of intelligence between human-nature, arguing that it should be considered as one. Especially with this kind of intelligence I tried to experiment with in the design of my own master project, by making these patterns of both nature and architecture very tangible and understandable. The next step could be to automatise it.

INTRODUCTION OWN MASTER PROJECT

From the very beginning of my architectural studies, I unconsciously used such systematic approaches/technology during the design process. It was only when we had to try to describe or analyse ourselves as designers that I really noticed this and started to focus more specifically on it. I did notice that I was very interested in the principle of patterns (languages), hence my previous research on this theme. But only after I started working at 'Architects in Motion' and after my internship abroad at 'LAVA-Laboratory for Visionary Architecture' all the pieces of the puzzle fell together. My interest was greater than just patterns (languages), hence this thesis in which I chose to expand my previous research with other systematic approaches such as parametric design and architectural intelligence. In which I first analyse the most important theories, then identify the published critiques and finally try to structure this knowledge so that we can make effective use of it during the design process.

Many people know that these techniques exist and may be intrigued by them, but they have no idea how to make use of them. Hence this case study in which I discuss how I have tried to apply these concepts within my own master project. **It is very important to note that this is only a possible conception or personal translation of the previous concepts, there are countless interpretations and design possibilities.**

It was immediately clear to me that I wanted to use these discussed techniques in my master project, considering that this is part of myself as a designer. This choice subconsciously caused me to adopt a certain mindset from the start, namely how I could best apply these systematic approaches/technology within the development of my own master project.

What is remarkable about previous theories/concepts is that they are often applied almost exclusively within an urban context. During the development of my own master project I will try to examine how these concepts can be applied to or translated in natural identities that are recognizable in the landscape. And then how, as a designer, one can correctly deal with these or make use of these.

It is important to point out that this research was developed in parallel in the design studio and in the seminar urbanism. In the seminar urban planning we zoomed out on the wider surroundings of Houthalen-Helchteren and how this area 'Ten Haagdoorn Heide' could actually function within the larger whole of nature reserves and collective places. While in the studio the specific focus on this area remained 'Ten Haagdoorn Heide' and 'De Teut'. How best to deal with this during the development of a certain identity or recreational structure within this beautiful heath landscape.

In short, this chapter describes the design process of my own master project and the parallel urban analysis we did on the wider region. This development was with a systematic approach in mind from the very beginning. How I translated or used the previous discussed techniques and theories, what the challenges were during this process, what to take into account when using these principles and how this guided the design process towards the outcome.

OWN MASTER PROJECT

0. ADAPTING URBAN THEORIES TO A NATURAL ENVIRONMENT

What is remarkable about the previous discussed techniques is that they are always focused on an urban or built-up environment. Only a few systematic approaches take into account landscape features or natural infrastructures present in our environment. Since these natural elements nevertheless play a very important role in our society, urban planning and architecture, it is very interesting to look at how they could be incorporated in previous systematic approaches/design patterns.

Since my master project is situated in a natural environment, namely the nature reserve 'Ten Haagdoorn Heide' and 'De Teut', this is something I have experimented with throughout my design process. In this chapter you can find out how I made the translation between for example natural features, different types of typical landscapes, natural infrastructures and architectural principles that respond to that.

The speculation and testing of this is endless. In my opinion there are infinite possibilities of architecture projects with a systematic approach (or a kind of pattern as a starting point) that interact with the built or natural context. So it is impossible to prescribe and name them all, this is the choice and task of the architect to experiment with this during the design process. However, it is possible to transform some already existing techniques into natural elements instead of rather physical or built elements.

For example the five elements of Kevin Lynch (1960), namely; Paths, Edges, Districts, Nodes and Landmarks could be interpreted as; Streams, Boundaries, Typologies of Nature, Viewpoints and the (most beautiful) Preservated Areas.

Furthermore, John Habrakens' theory could also be adapted as a balance between human and nature instead of between the professional and the user. The levels could then be divided as: natural landscape, different typologies of nature, vegetation and animals, strategic structures, recreational activities.

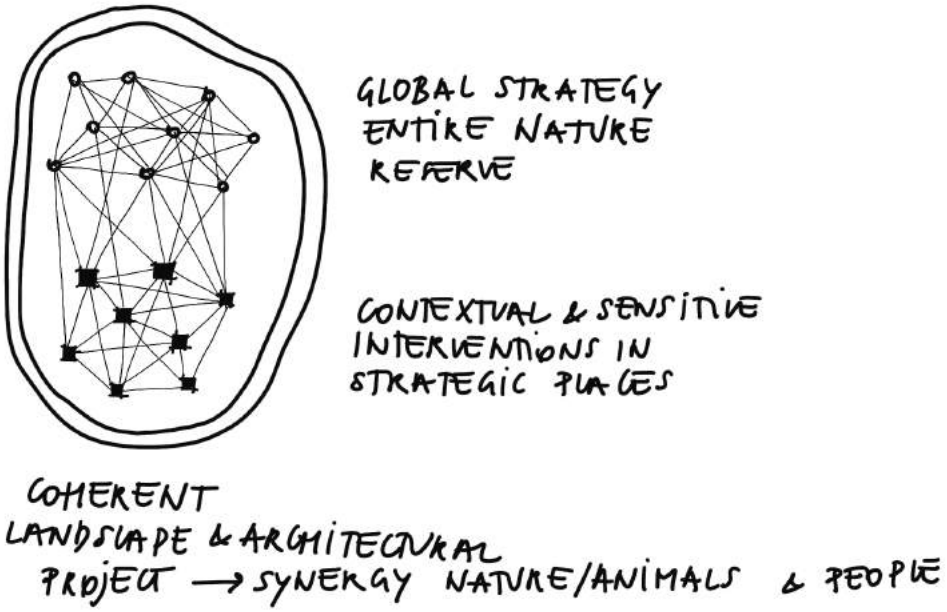
In order to be able to base ourselves on a natural rather than a built-up or urban environment, it is very important to know the landscape sufficiently first. This requires thorough preliminary research. Then we know what the typical types of vegetation are and where they just occur (e.g. parallel to the riverbank). In this way, different typologies can be recognised. By this I mean different types of landscapes for example; a dense forest, a rather open area with a few isolated trees, a lavender field or a drifting sand ridge. The next step is that one can choose which element of the systematic approach can interact with this. This can range from the rhythm of the facade layout to the complete organisation of the ground plan, for example.

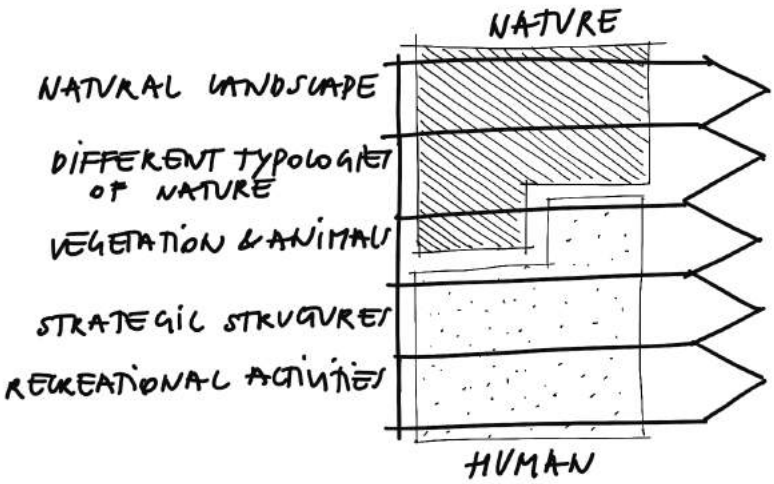
Just because there has been so little experimentation by architects on this subject, this makes it very interesting to investigate while designing.

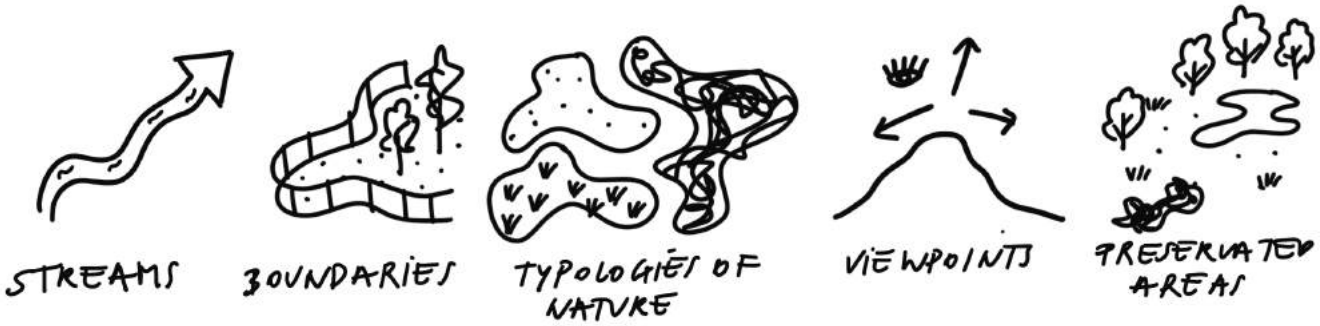
But what is most important if we want to achieve a coherent architectural and landscape project in which a synergy between man and nature is achieved, is that we develop a global strategy for the entire nature area after extensive research. Subsequently, very context-sensitive interventions can be designed in a few strategic places.

OWN MASTER PROJECT

0. ADAPTING URBAN THEORIES TO A NATURAL ENVIRONMENT







Natural diagrams of own production, Bo Westerlinck

OWN MASTER PROJECT

1. ANALYSIS URBANISM

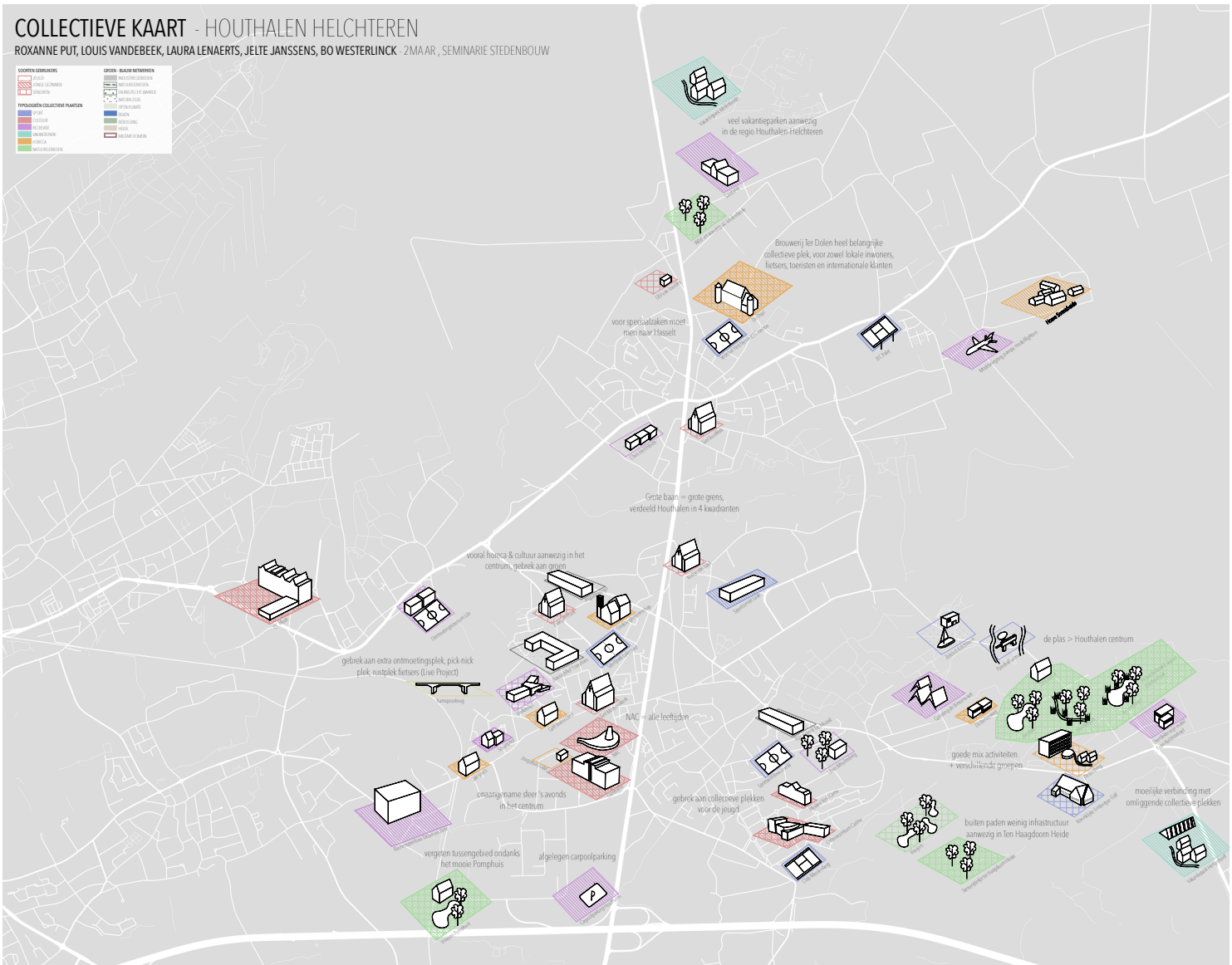
1.1. COLLECTIVE SYSTEM - OWN PATTERN LANGUAGE

After a thorough urban analysis of all the collective places present in the area Houthalen-Helchteren, we developed our own pattern(language) to represent these different places. Within these patterns or simplified icons, clear families of collective places can be recognized (e.g. sports fields, natural attractions, religious buildings or rather box-shaped buildings). Furthermore it was also important to us that they stayed recognizable for the citizens.

We also added a support base under these simple icons. The colour of this base indicates to which category of collective place it belongs (nature reserves, holiday parks, culture, sports, catering or recreation). In addition, we also studied the different types of users of these collective places, which we divided into three different groups: youth, young families and senior citizens. These are recognizable by the different shading of the support bases (e.g. dots, checked, diagonally lined).

Finally, the size of the support base also reflects from how far people come to these places or how important this collective place is within the community.

After this analysis our eye was mainly drawn to the system of collective places situated around 'the lake' in Houthalen-Helchteren. This good mix of activities situated in between beautiful nature caused a great appreciation by all the different age groups. Another interview even showed that people prefer this area as a collective space rather than the centre itself.



Urban analysis map collective spaces, own production, Bo Westerlinck

OWN MASTER PROJECT

1. ANALYSIS URBANISM

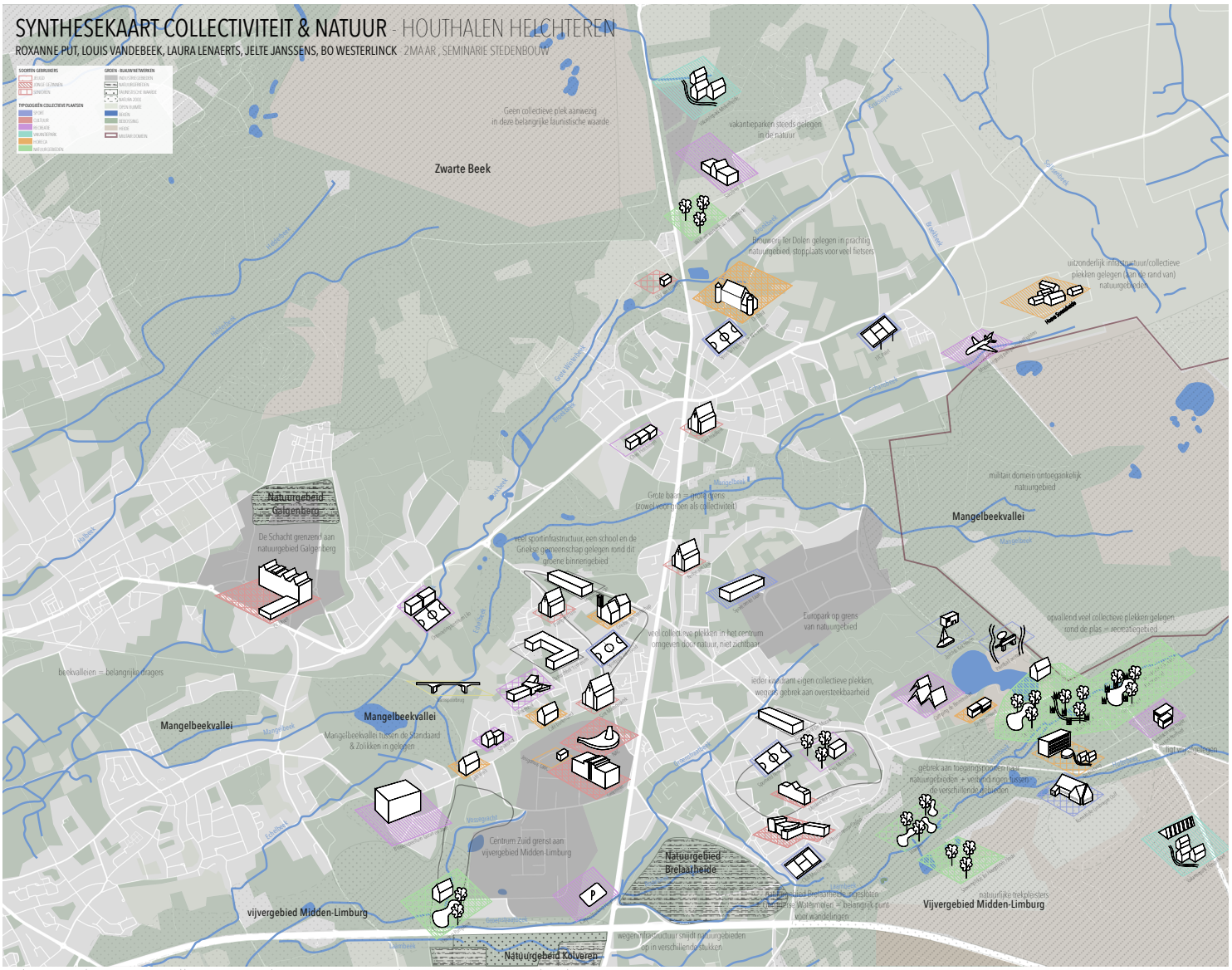
1.2. COMBINATION COLLECTIVITY & GREEN-BLUE INFRASTRUCTURE

Because of the remarkable similarities between collectivity and green-blue infrastructure, we combined the research of these two themes into one map. Again, the area of 'the lake' stood out because it is situated between two nature reserves and because it is recognized as such an important collective area by the local citizens.

In addition, it was immediately clear that there was a lack of gateways to these valuable nature areas and connections to counteract their fragmentation. The beautiful nature is a great strength of Houthalen-Helchteren, thus we should emphasize this more.

Furthermore the rivers that are orientated east-west, in contrast to the large trajectory that runs from north to south, deserve much more attention. How can we deal with this in an appropriate way to help solve local problems such as drought and flooding?

Although the map looks very green at first sight, this is not very noticeable when you are in the centre or when driving on the 'big lane'. This is a missed opportunity where we should try to formulate a solution for. This is to ensure that both tourists and residents experience the area as green as it is and to ensure that this beautiful nature can be observed and appreciated in a respectful way.



Urban analysis map collectivity and natur, own production, Bo Westerlinck

OWN MASTER PROJECT

1. ANALYSIS URBANISM

1.3. CREATING IDENTITY FOR THE NATURE RESERVE

The specific area I will focus on during the design studio is called 'Ten Haagdoorn Heide' and 'De Teut'). This is a beautiful nature reserve of 360 km big, that is characterized by a heather landscape with lavender, drifting sands, forests and other shrubs. It is also referred to as the purple heart of the province Limburg in Belgium. Many animals feel at home here; the smooth snake, the tree lark and the spout for instance.

Despite its beauty, the area is relatively unknown to many people who aren't living in the close environment of it. Furthermore, there is hardly any infrastructure present, except some pathways and a few benches. This causes a lack of variety of functions that can be carried out there, in a respectful way of course.

Moreover, this area also has problems of drought in the small lakes that are present along the river the 'Laambeek'. And in order to maintain this heather landscape it requires great effort and specific attention. In fact, the area is grazed by 350 sheep in order to naturally maintain the heather's ecosystem. In addition, there is also mechanised tillage, where the top layer of the soil is scraped off so that there is room for new heather plants to grow. There is also a real lack of data from similar nature reserves, we don't know enough about what is happening there exactly. And as already mentioned, the road infrastructure divides the many nature reserves into pieces. This nature reserve is divided into two pieces by the highway E314, the top is called 'Ten Haagdoorn Heide' and the bottom part is called 'De Teut'.

It is my ambition to bring people back closer to nature and at the same time connect them with each other. In my opinion this area has a great opportunity to become an important community point. During the design studio I will research and test how an architectural project can formulate an answer for this. How can we create an identity for this nature reserve, in order that it would be appreciated and used more in a respectful way?

Nature reserve Ten Haagdoorn Heide, own production, Bo Westerlinck

Nature reserve Ten Haagdoorn Heide, own production, Bo Westerlinck

1.4. CONCLUSION URBAN ANALYSIS

What we can mainly conclude from the urban analysis is that Houthalen-Helchteren suffers very badly from fragmentation by the road infrastructure. This both on a collective level and in terms of the green-blue infrastructure. Each quadrant functions as a small system on its own, because people prefer not to cross the 'big road' if they don't really have to.

In addition, when looking to the combined analysis map it looks like a super green area with many valuable nature reserves, but this is not really noticeable from this 'big road' or when you are in the centre. This is a great opportunity to do something with as urban designers/architects. In this way we can connect the people back to nature and with each other at the same time. Of course, we always have to make sure that this is done in a very strategic way with the highest respect for these valuable nature reserves.

OWN MASTER PROJECT

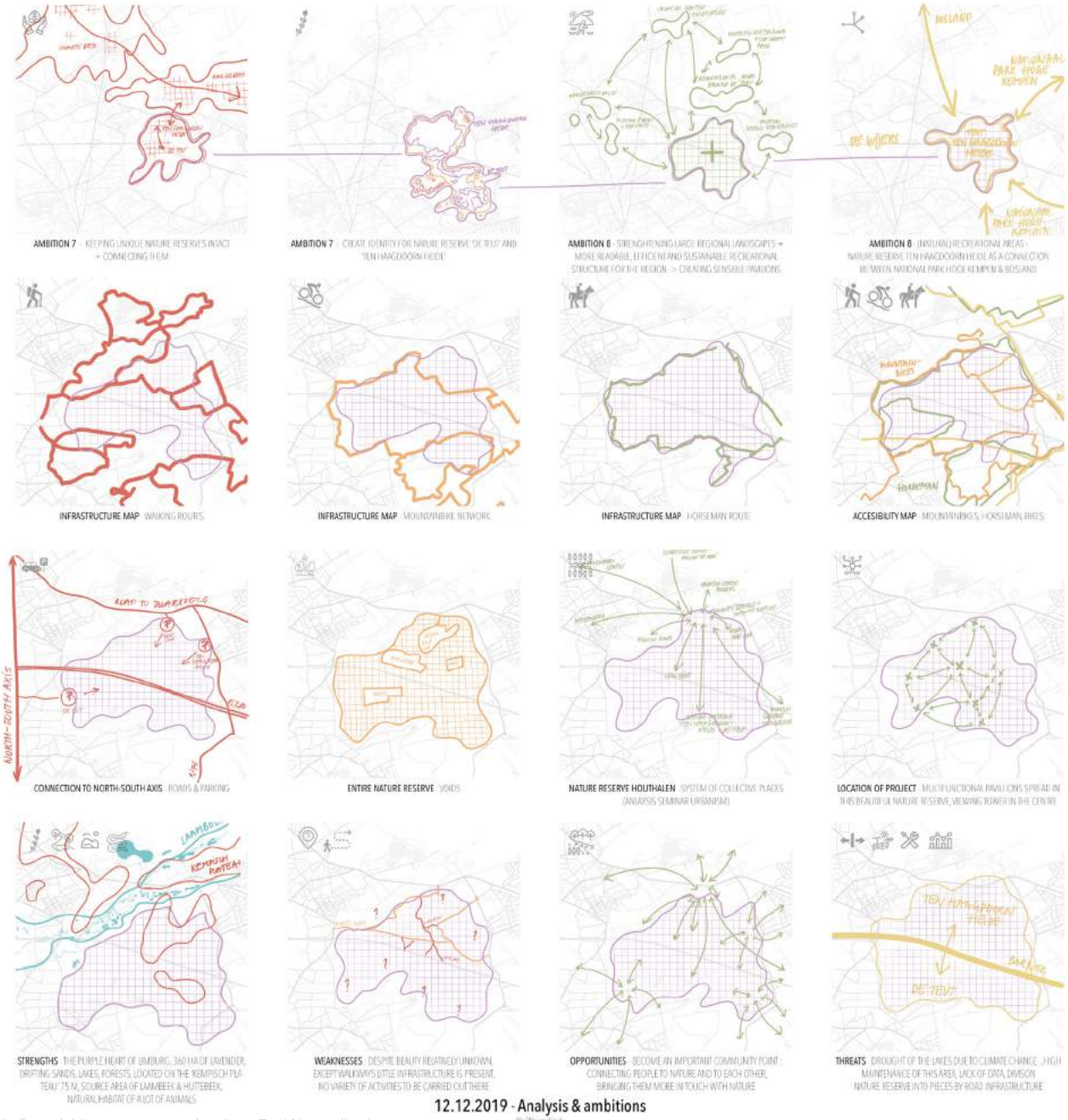
2. IDENTIFICATION CHALLENGES

2.1. DESIGN DEVELOPMENT

2.1.1. LINK TO AMBITION NOTE & LINK TO URBAN ANALYSIS -> CONCEPT DEVELOPMENT

Within the design studio 'New Economies' we join the research on the North-South Connection going from Eindhoven to Hasselt. This important connection has been under pressure for a number of years on various aspects; the road infrastructure has a splitting effect on the villages it passes through, it divides the natural areas into pieces, intersects the many streams and almost every day there are miles and miles of traffic jams due to insufficient road infrastructure.

Within this research I would like to focus on ambition 7 and 8. Ambition 7 is about keeping the unique nature reserves intact, connecting them where possible and creating an identity for them. Ambition 8 focusses more on how we can create a more efficient, readable and sustainable (natural) recreation both on a local scale and in the larger system of nature reserves.



Analysis & ambitions, own production, Bo Westerlinck

OWN MASTER PROJECT

2. IDENTIFICATION CHALLENGES

2.1. DESIGN DEVELOPMENT

2.1.2. ANALYSIS NATURE RESERVE - PATTERNS/PARAMETERS FOUND IN NATURE

First of all I tried to start from the idea to use a kind of systematic approach from the beginning of the design studio or attempted to develop my own pattern language in each of the different tests/ideas. Throughout the process, however, this changed whether it related to how a system of collective places could emerge that worked together, how the same typology of buildings could lead to multiple buildings that were always adapted to different circumstances, or how a structure could be expanded as the function or needs changed. This is something I already unconsciously did in my previous projects as a kind of guiding principle during the design process to generate the best possible design for every complex design task.

Of course there are still countless possibilities how to apply this properly, what kind of system you develop or how a certain system can be adapted to different locations/ functions/contexts, etc... This makes it a very interesting theme to experiment with during the development of my master project.

What an extra challenge is with this project is the fact that my design is not situated in an urban or built-up environment but in a natural context. In previous projects, however, this was always the case. **Thus I challenged myself to see if I could convert the parameters I found in nature to a certain architectural principle within my project.** For me, the clearest parameter was the different types of nature that were present in this nature reserve, namely; very open drifting sands, lavender-like shrubs, some isolated trees in an open field or a dense forest.

In the test 'community gate' I used the width of the arches as a direct reflection of the different types of landscape behind it. The arch became more narrow as it became a more open and calmer landscape. When there were a lot of trees close to each other, this arched opening became much wider as the trunks of the trees already caused a dense division.

In the next trial 'separate pavilions' the density of nature was literally reflected in the arrangement or density of the circle-shaped architecture. When the nature is very dense, the circles merge together completely, when it is slightly less dense they overlap, then they only touch each other and when it is a very open field they are scattered and separate from each other. The reason for this combined circular arrangement is that it is the most compact form in order to have a minimum impact on the valuable nature, it also provides panoramic views to the beautiful surroundings and a very even incidence of light.

Although both started from the same kind of systematic approach using the different types of nature found in this nature reserve, it resulted in two very different kinds of architecture. This proves once again that there are countless possibilities for making use of such systematic approaches within an architectural project. In addition, in the second trial 'separate pavilions' the impact was also greater as it really influenced the arrangement of the building, while at the 'community gate' it only changed the facade and arches of the gallery.

2.1.3.INPUT URBAN WORKSHOPS & COUNSELLING MOMENTS

It is important to mention that the design studio is a very intensive search for the best possible design solution for your own established goals and ambitions. A small presentation will be held every week, after which feedback will be given on what you could try, what things you should adjust or how best to modify your project.

During the seminar urbanism we also had the opportunity to interview local inhabitants and attend various workshops involving key players such as civil servants of Houthalen-Helchteren, the self-employed or members of important nature organizations. Consciously or unconsciously, these of course also influenced the further development of this design project and the various options that were tested.

OWN MASTER PROJECT

2. IDENTIFICATION CHALLENGES

2.2. TRIAL AND ERROR

2.2.1. HYBRID BUILDING - MATERIAL AS A GUIDING PRINCIPLE

The first assignment of our studio was to design a hybrid building with a maximum size of 12 x 12 x 20 meters. **The intention here was to focus specifically on a certain material and thereby develop a structural principle, this completely context-less.** Within the development of this project I chose to work with hempcrete, a very sustainable material with a very natural outlook. Normally this is a very solid material with almost no openings. By working with arches, it was possible to create several self-supporting openings in this structure.

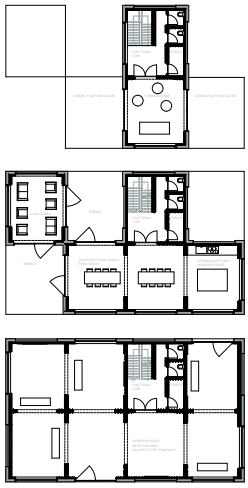
Then I used these structurally determined dimensions to determine a grid, in which subsequently different volumes were placed. It was a specific choice not to build to the edges of the full maximum volume to create a more dynamic project with interaction between all levels. In this way, terraces on the first floor and a small viewing platform were created.

Furthermore I also did a test with an algorithm I created in Grasshopper to test out different compositions of these 'cubes'. This was depending on how many cubes you wanted on each level and was organised randomly. This made it very easy to test out several options or to modify this project according to the needs/ wishes of the future users.

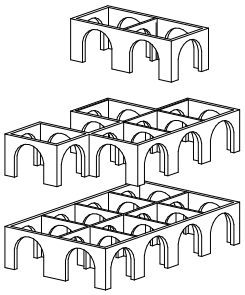
HEMPCRETE CENTRE

CONNECTING COMMUNITY TO NATURE

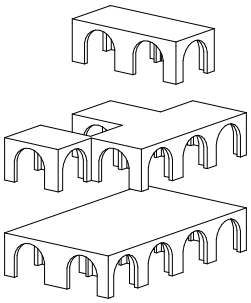
GRID ORGANISATION + FUNCTIONAL CORE



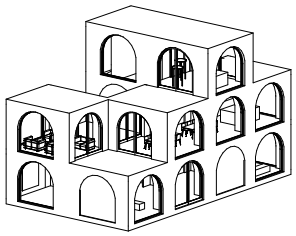
BRICK STRUCUTURE INSIDE



COVERED WITH HEMPCRETE



FILLING IN OPENINGS ACCORDING TO NEEDS (CLOSED WALL, WINDOW, DOOR)



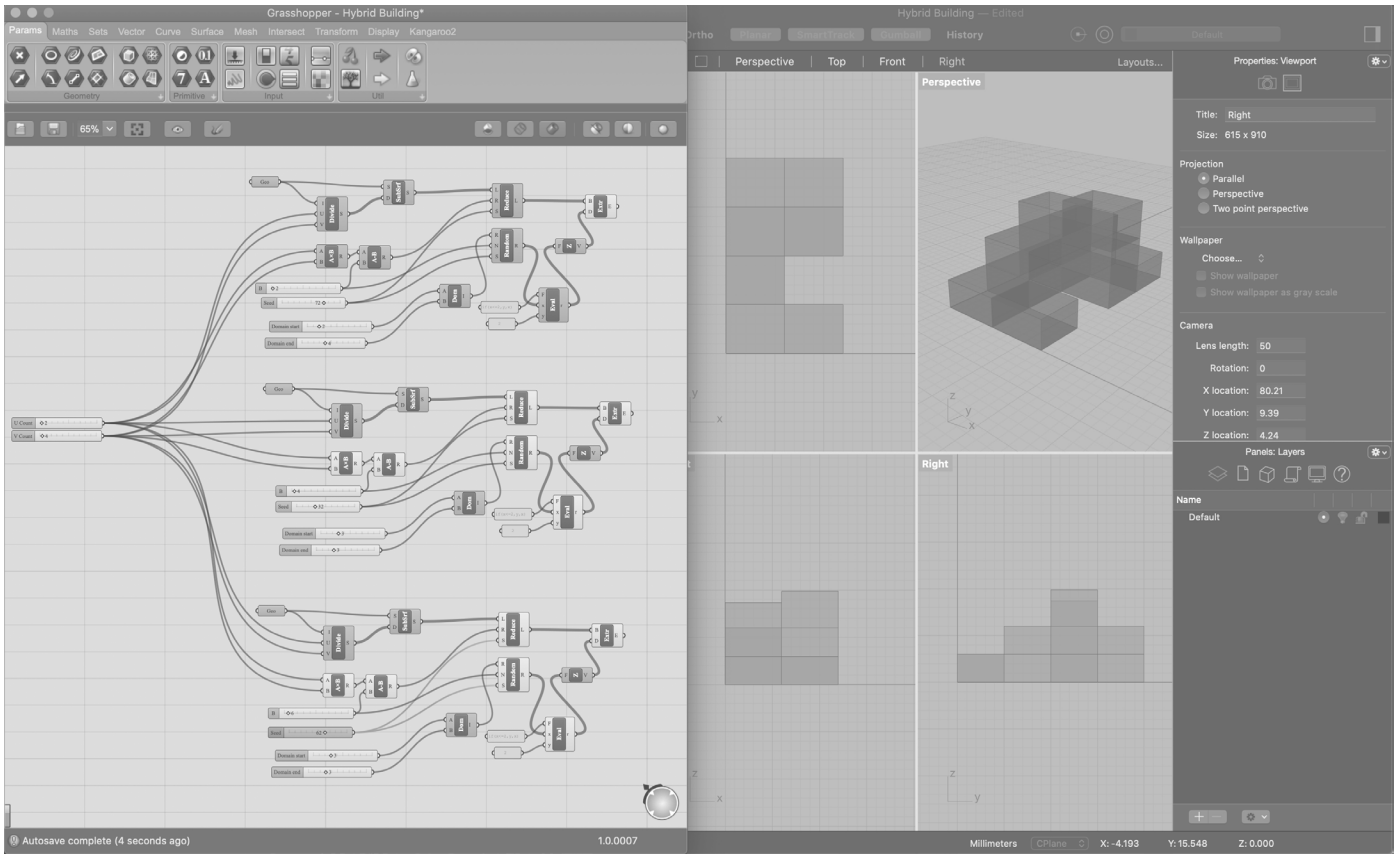
Hybrid building design panel, own production, Bo Westerlinck

OWN MASTER PROJECT

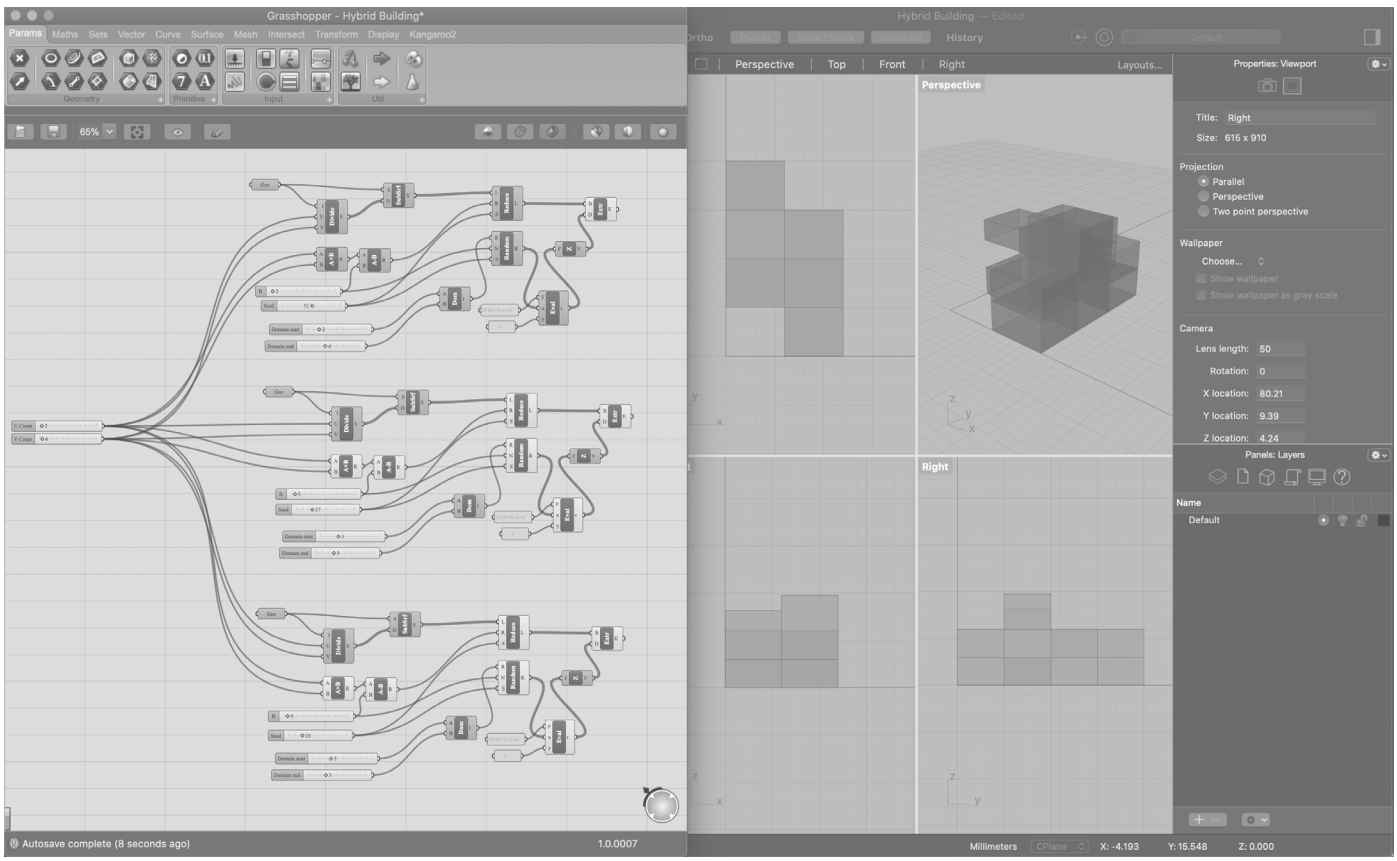
2. IDENTIFICATION CHALLENGES

2.2. TRIAL AND ERROR

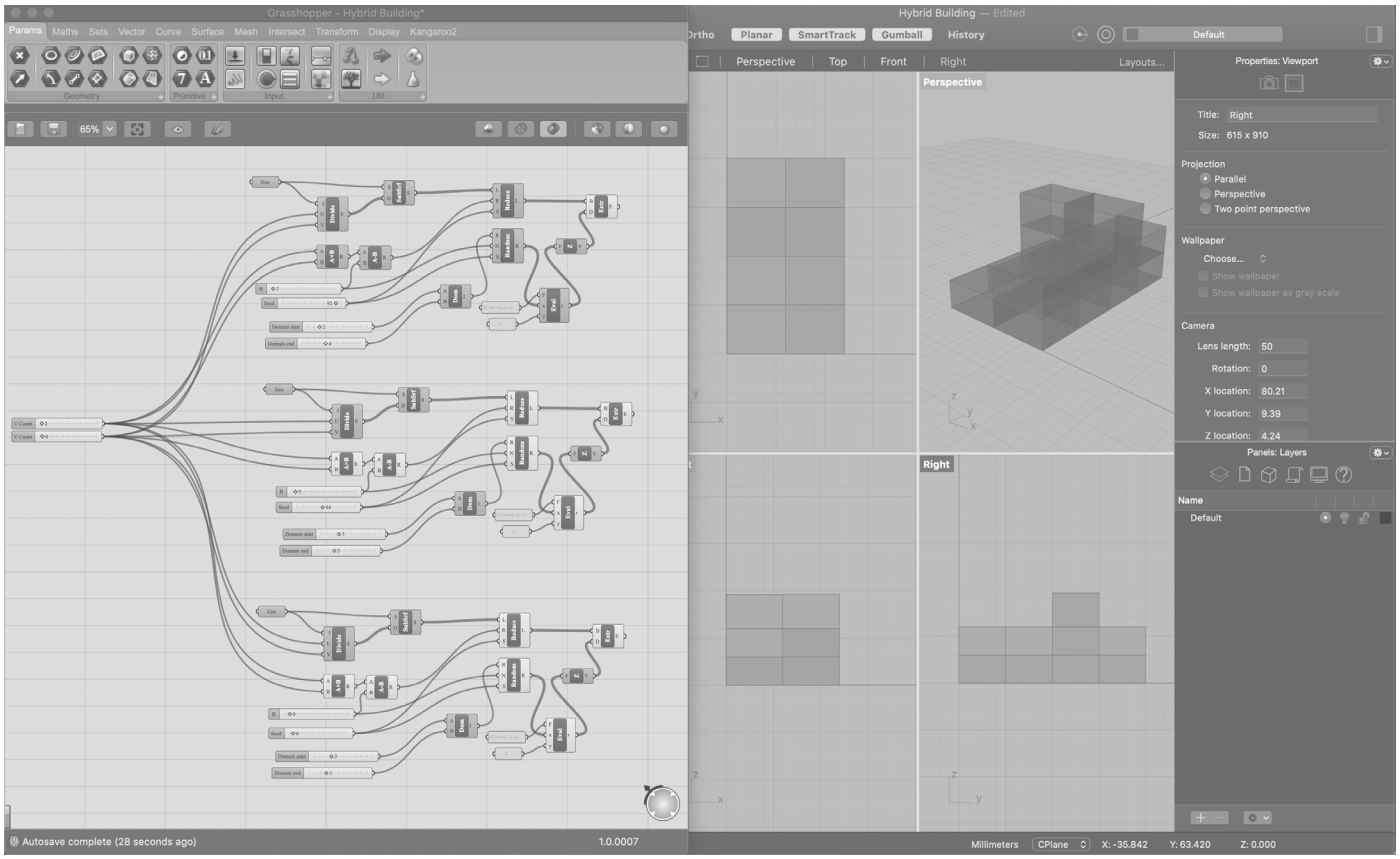
2.2.1. HYBRID BUILDING - MATERIAL AS A GUIDING PRINCIPLE



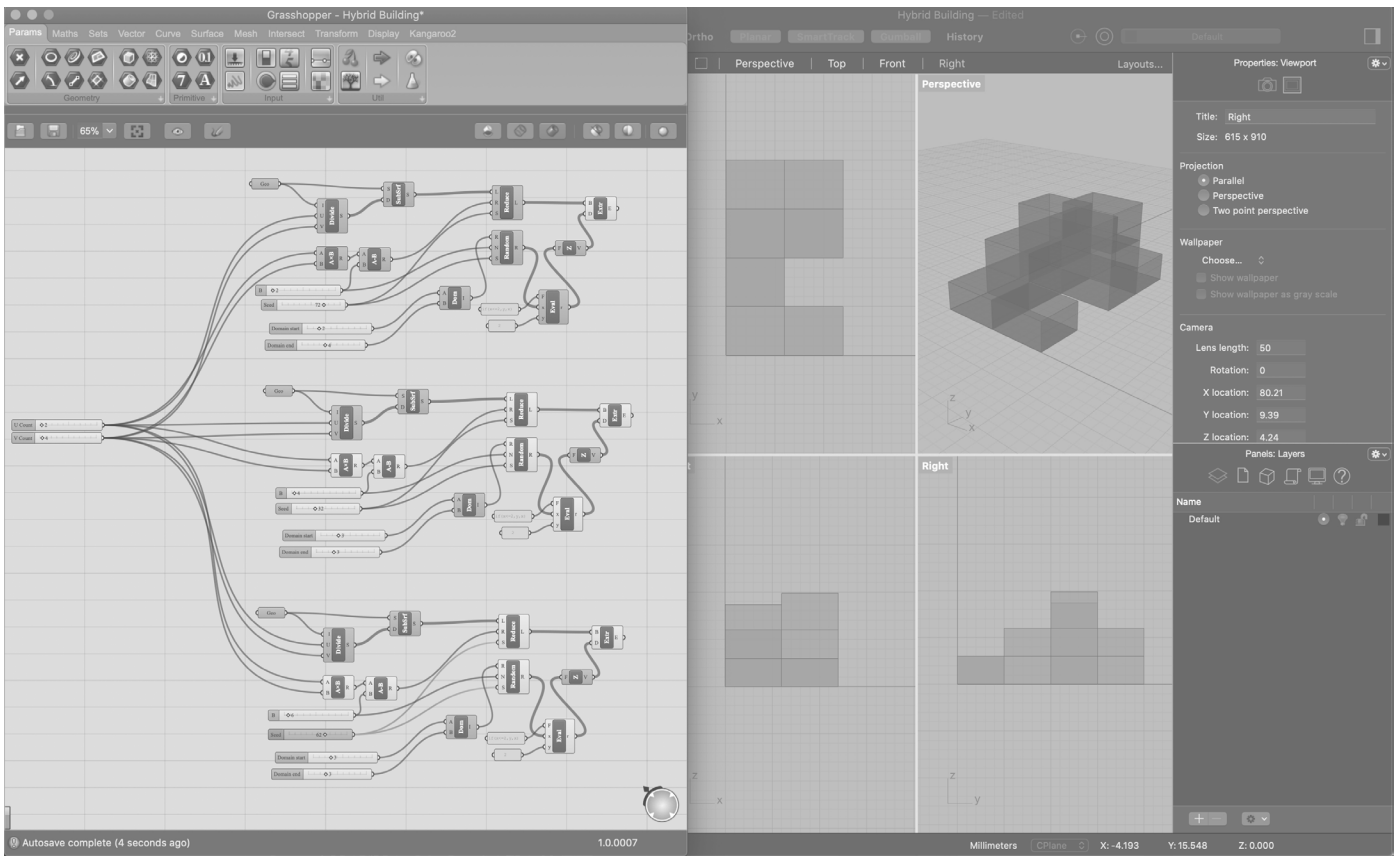
Algorithm Hybrid Building Grasshopper-Rhino, own production, Bo Westerlinck



Algorithm Hybrid Building Grasshopper-Rhino, own production, Bo Westerlinck



Algorithm Hybrid Building Grasshopper-Rhino, own production, Bo Westerlinck



Algorithm Hybrid Building Grasshopper-Rhino, own production, Bo Westerlinck

OWN MASTER PROJECT

2. IDENTIFICATION CHALLENGES

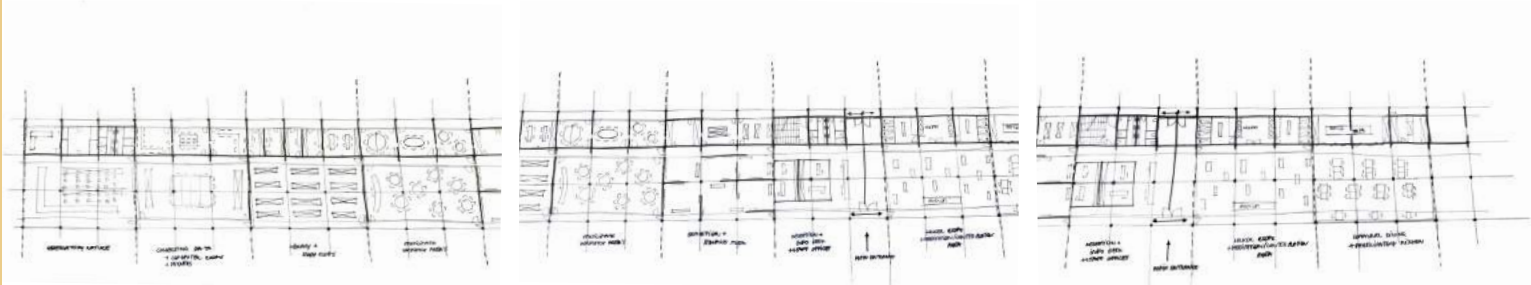
2.2. TRIAL AND ERROR

2.2.2. COMMUNITY GATE - ADAPTING THE STRUCTURAL PRINCIPLE TO LOCAL CONTEXT

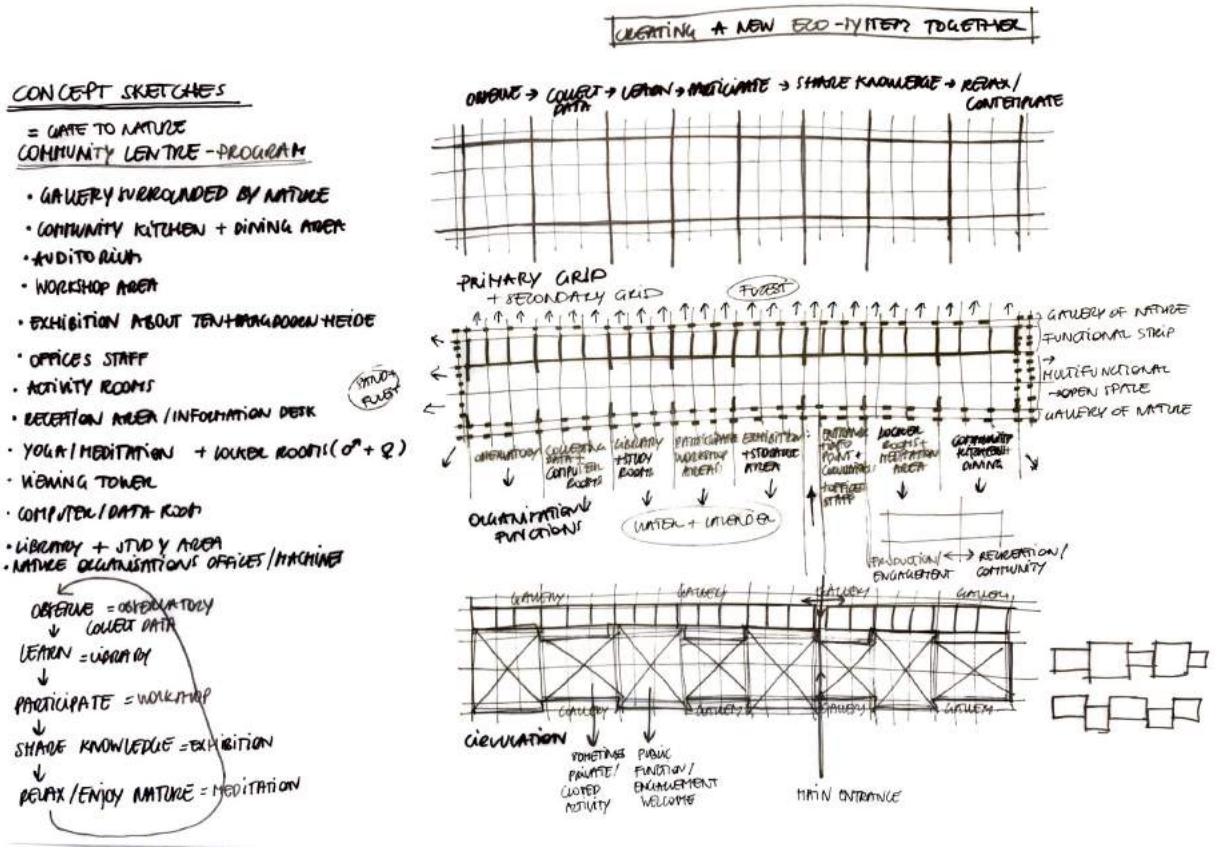
Next, for the studio's second assignment, called 'Designing the Public Space', it was intended that we would try to embed this structural principle from the previous assignment in a specific location and also adapt it to the local context.

I chose to embed my building on the edge of the nature reserve 'Ten Haagdoorn Heide', to make it function as a gateway to this area. I then chose to incorporate a community centre in it; where people could come together and enjoy the beautiful surrounding nature. Or where people could stop during a walk or bike ride for example, to relax or to learn about the nature reserve. This is the reason why I called it a 'Community gate', because this is the best way to describe the purpose of the project.

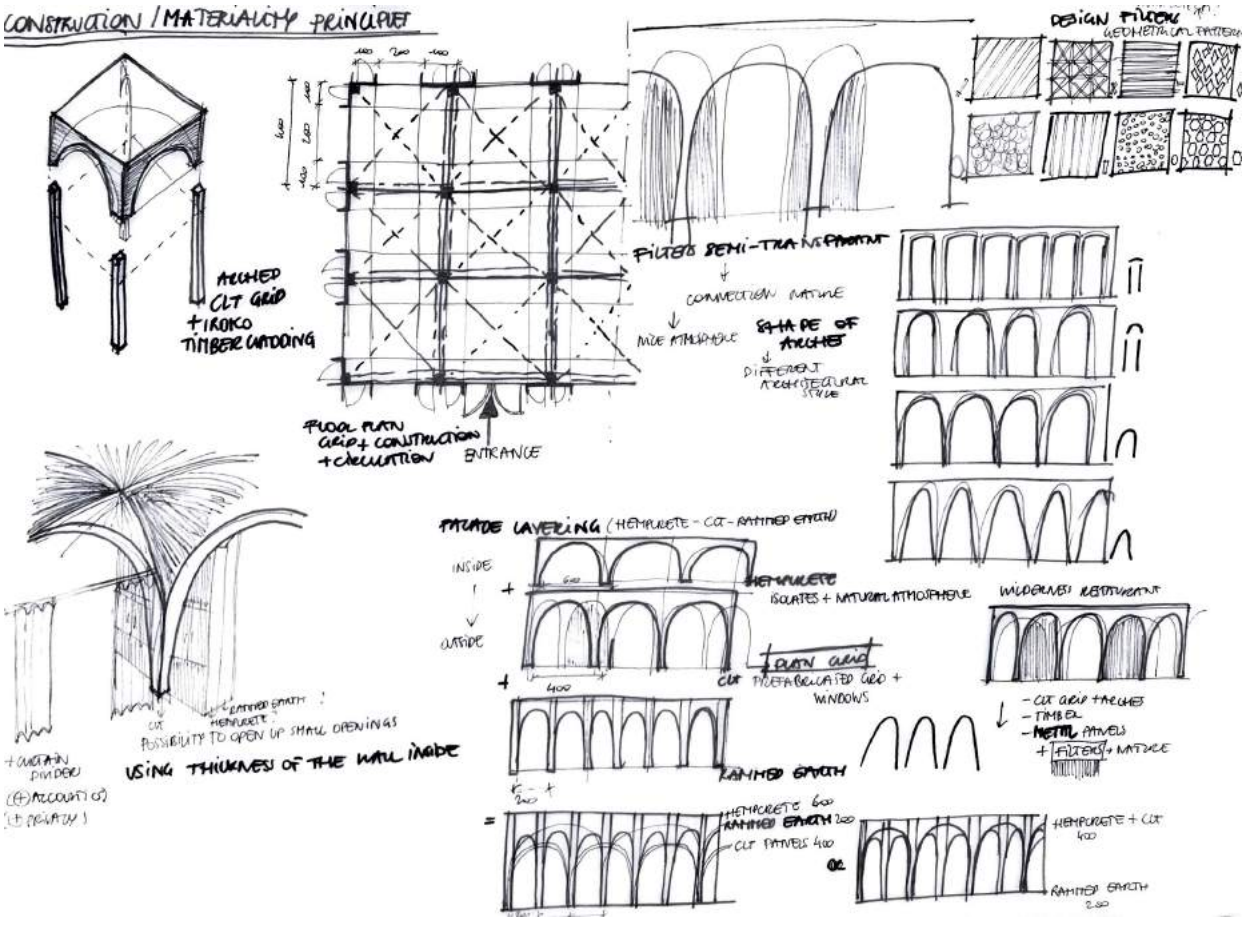
It included functions such as; a community kitchen with dining area, a small auditorium, workshop spaces, a small library, exhibition space about this area and a yoga/meditation space... The intention was that people could first observe the area, then learn from this, thereafter participate together in a workshop to share this knowledge with each other and finally relax and enjoy nature. Moreover, there was also room to collect data about the nature reserve and to play a (wild)live camera in order to get a closer look at what was happening in the nature reserve. Furthermore by placing part of the volume in the slope, a viewpoint over the surrounding area was created at the end of the building that was highest above the ground.



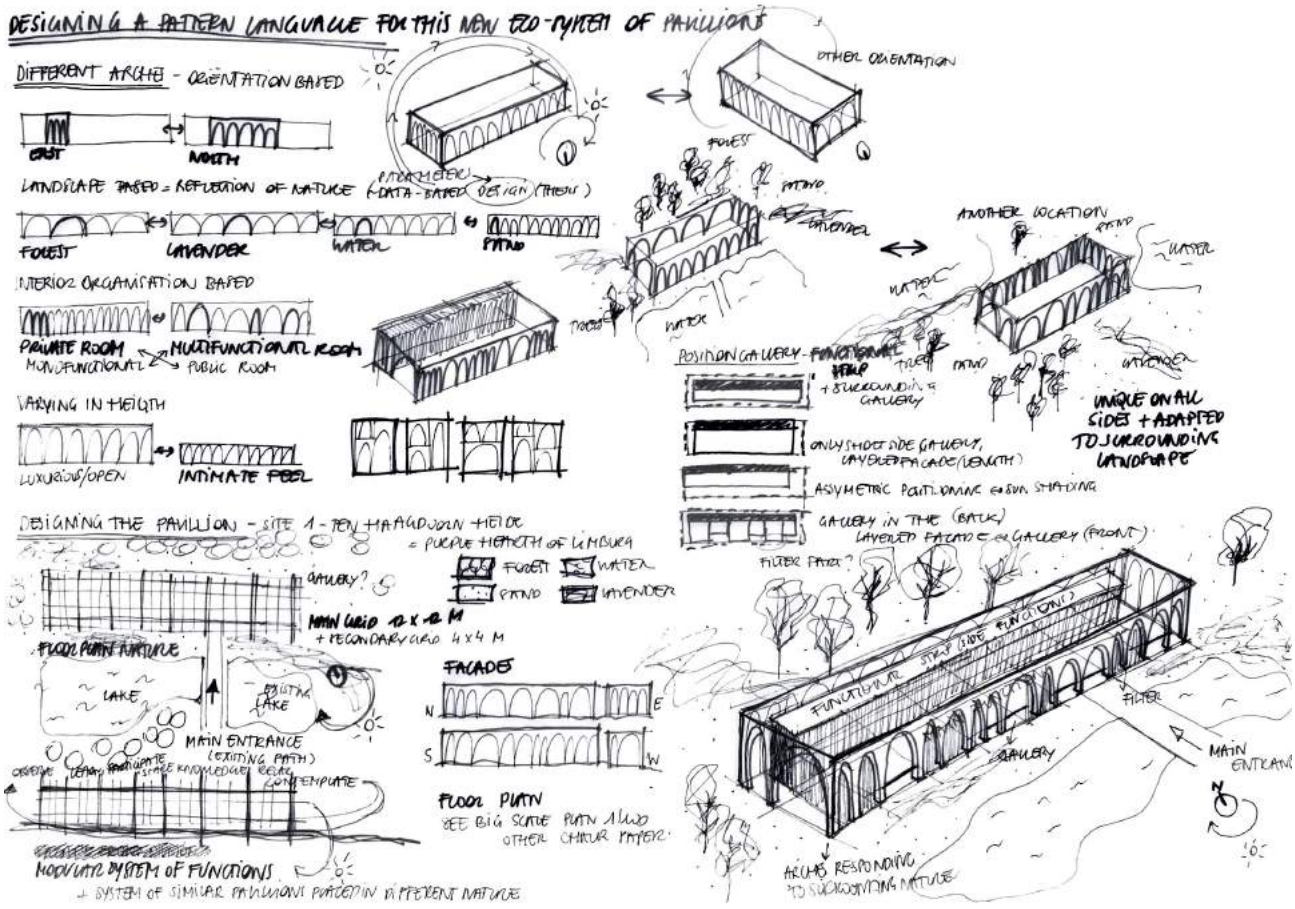
Floor plan Community gate, own production, Bo Westerlinck



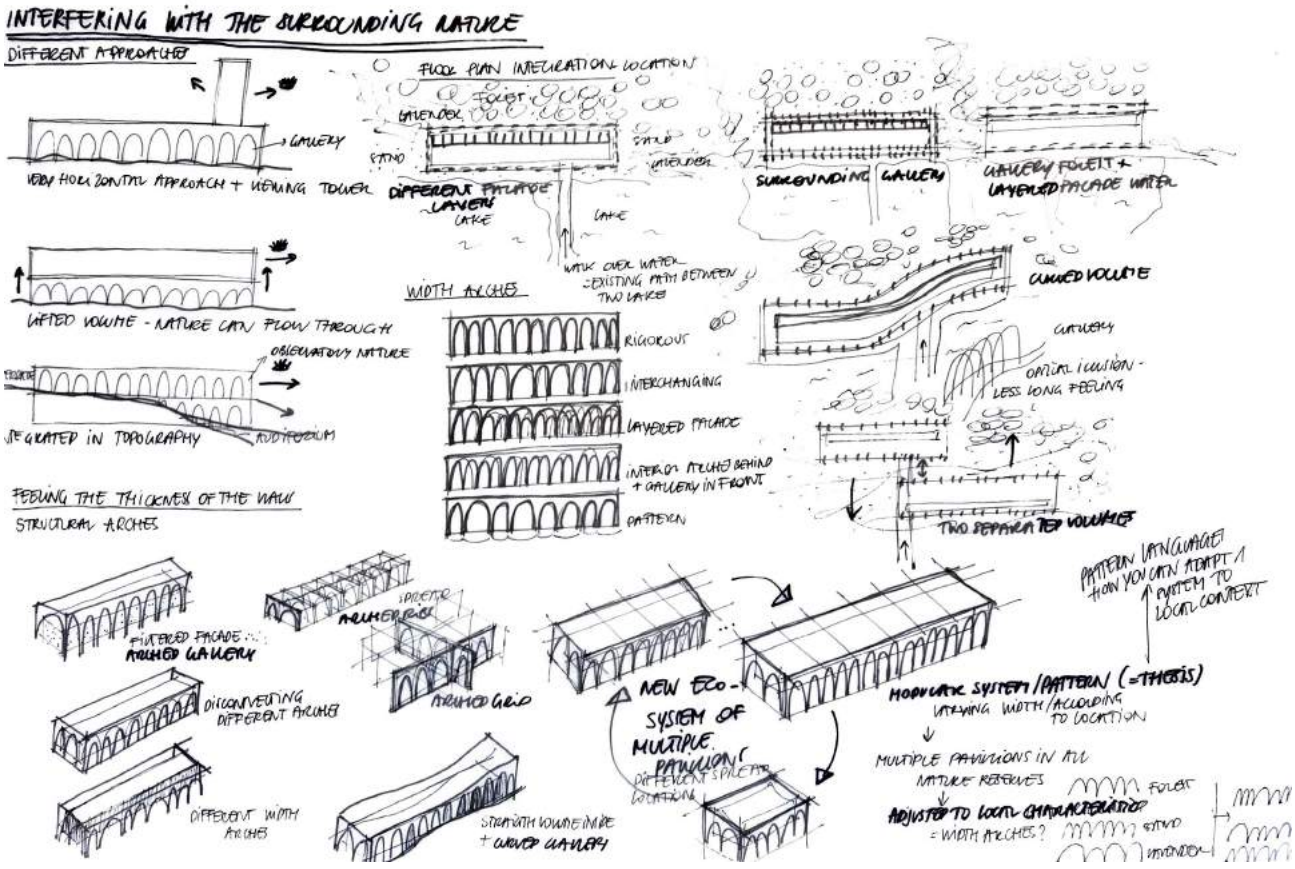
First ideas Program and Organisation Community gate, own production, Bo Westerlinck



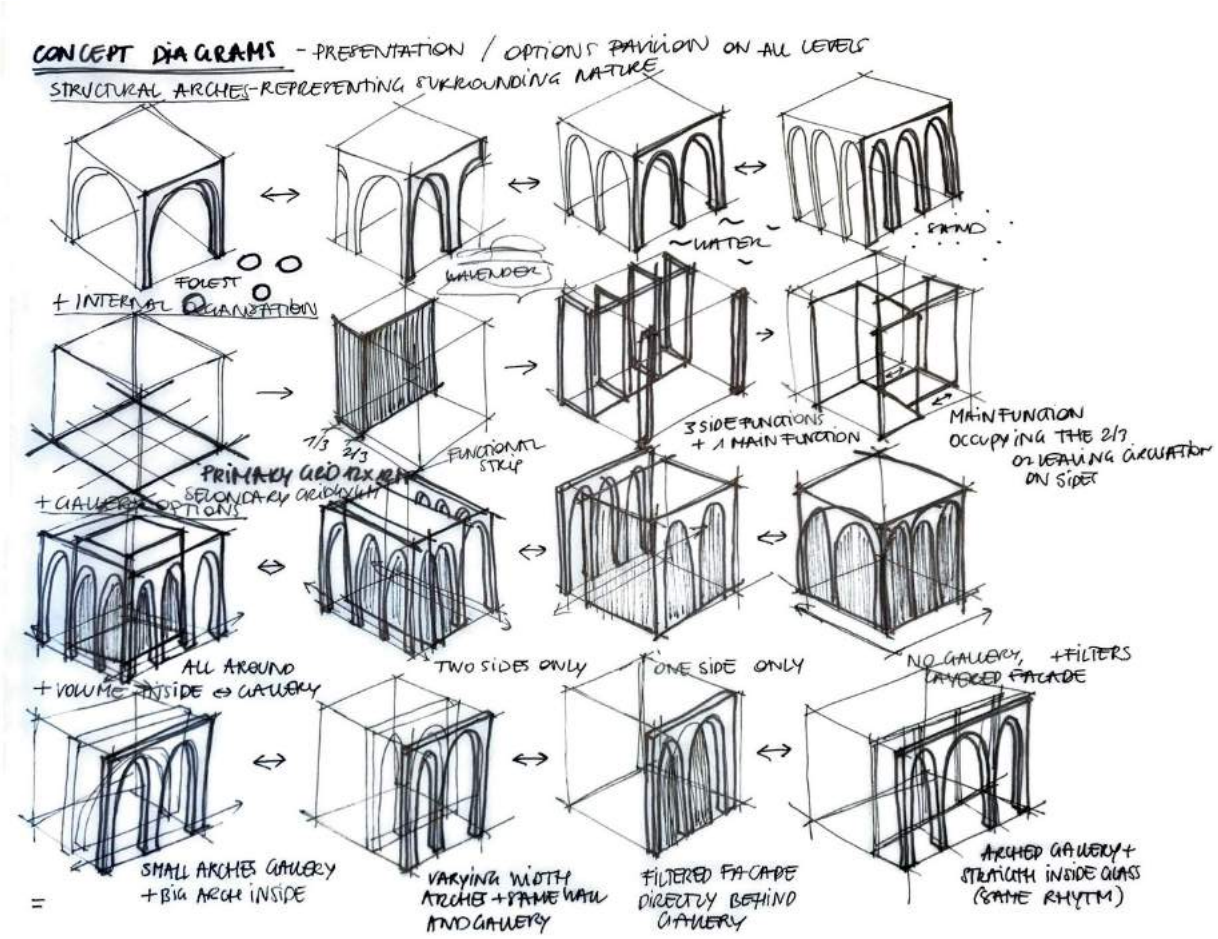
First ideas Structure Community gate, own production, Bo Westerlinck



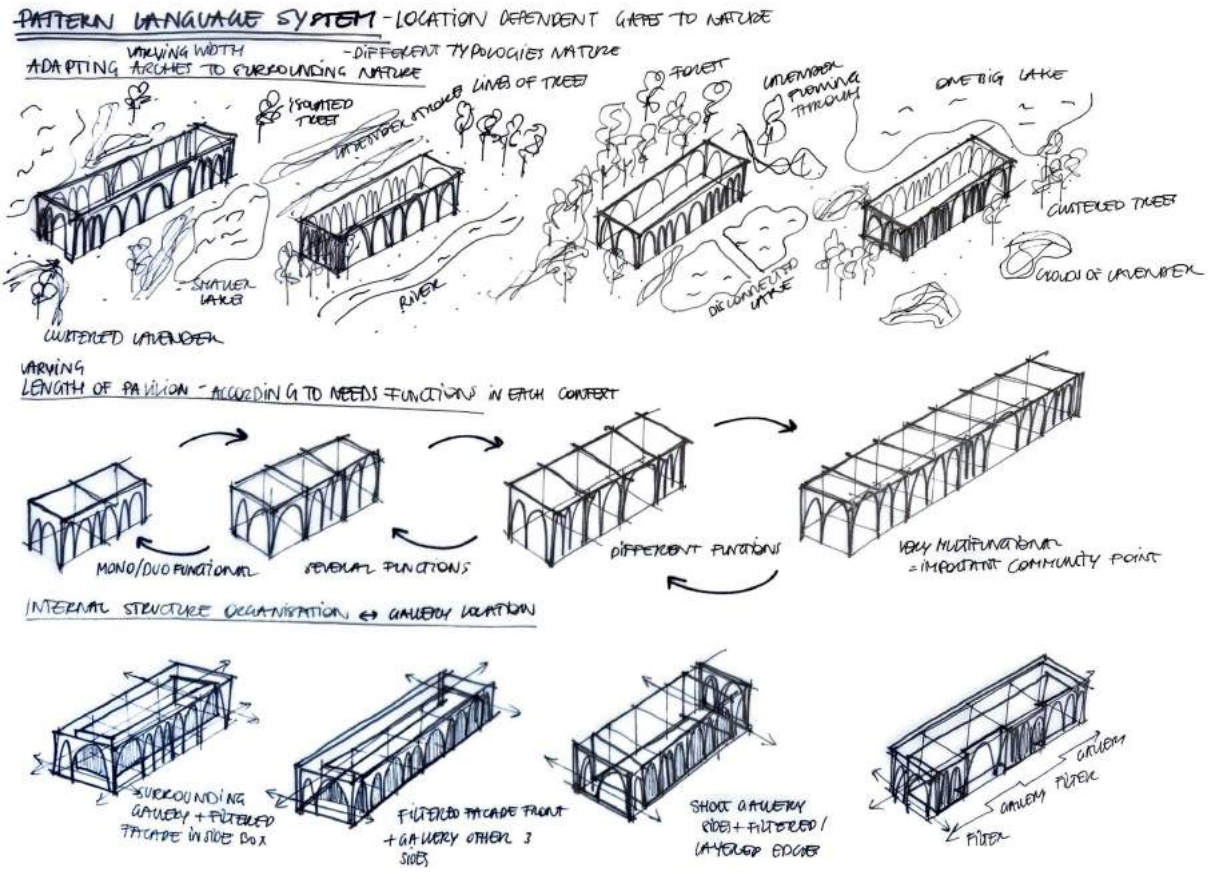
Design sketches community gate, own production, Bo Westerlinck



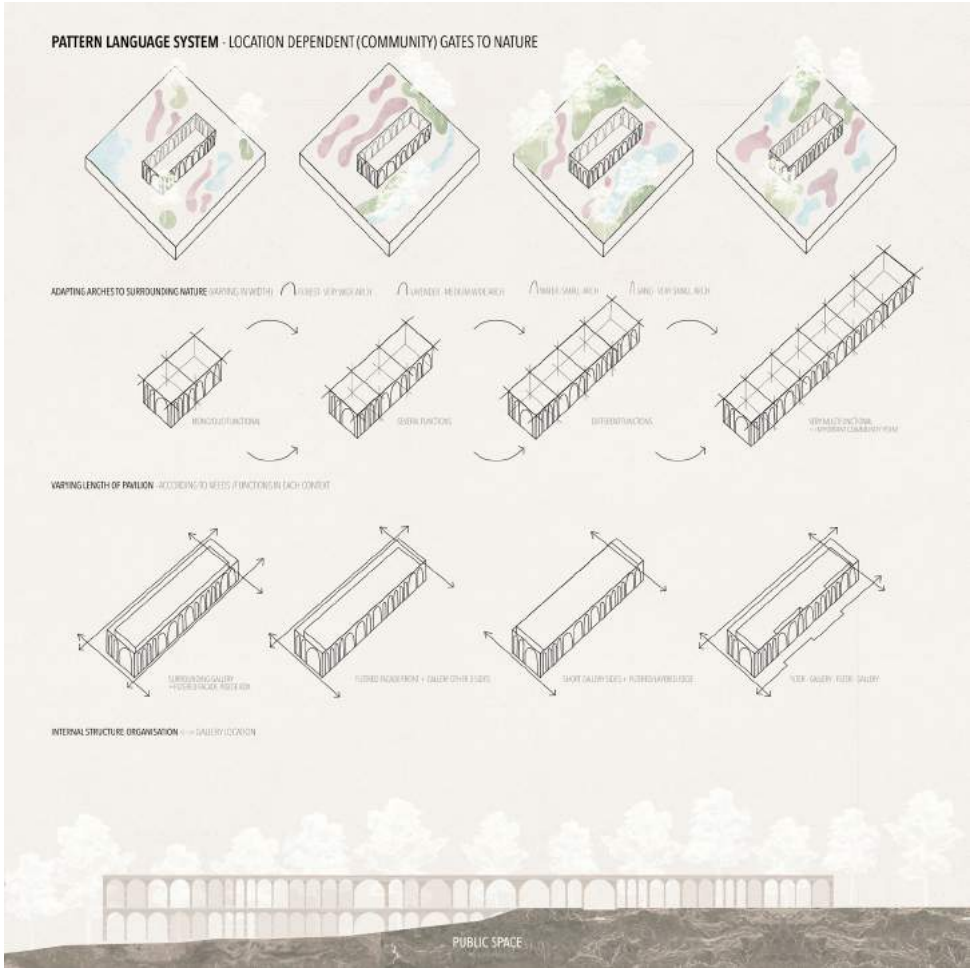
Design sketches community gate, own production, Bo Westerlinck



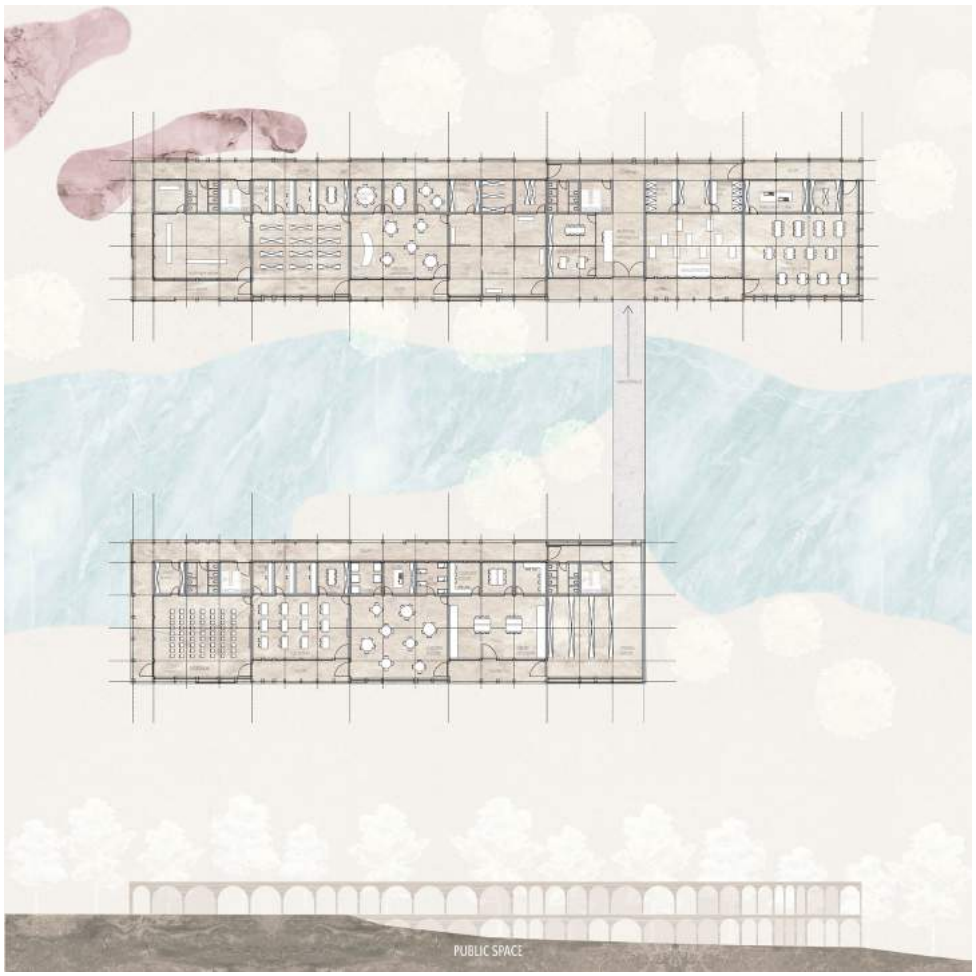
Design sketches community gate, own production, Bo Westerlinck



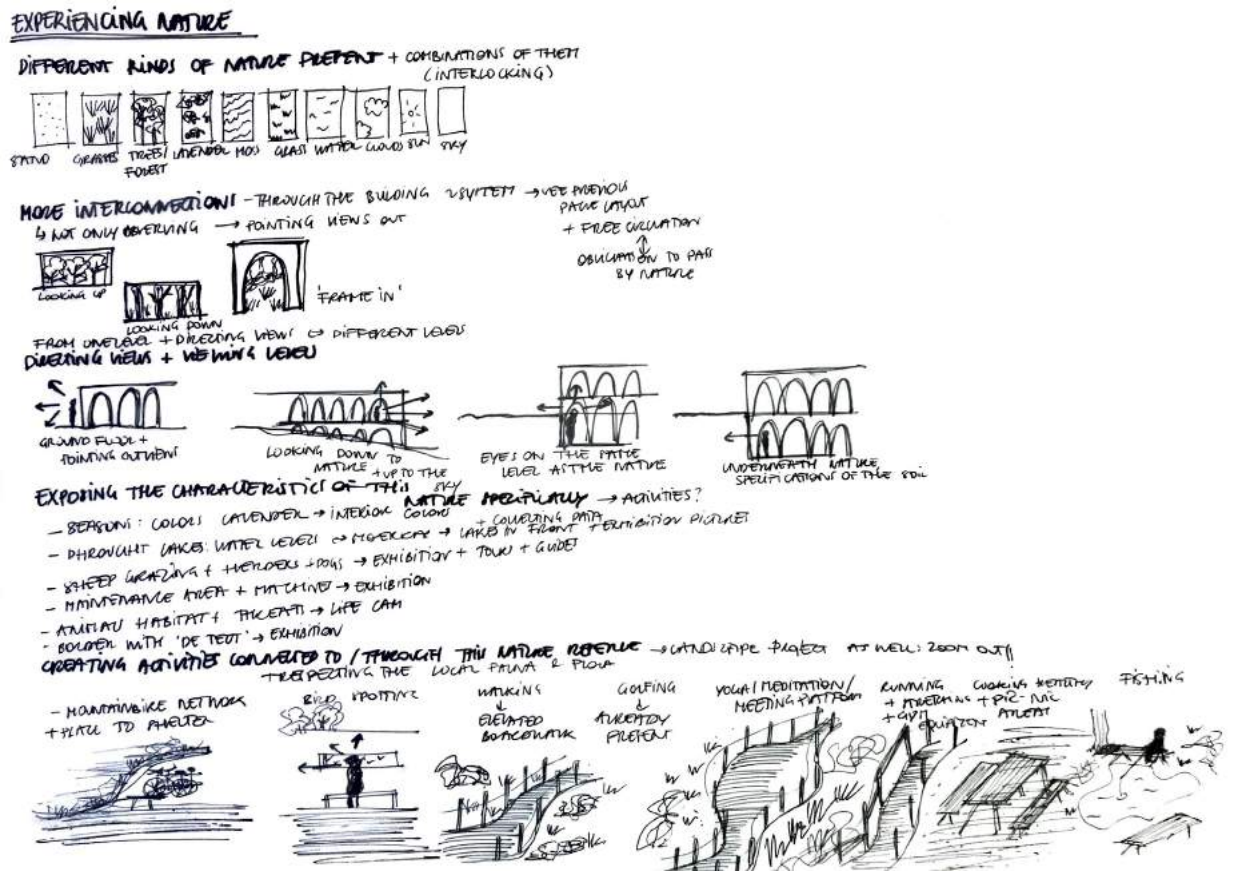
Design sketches community gate, own production, Bo Westerlinck



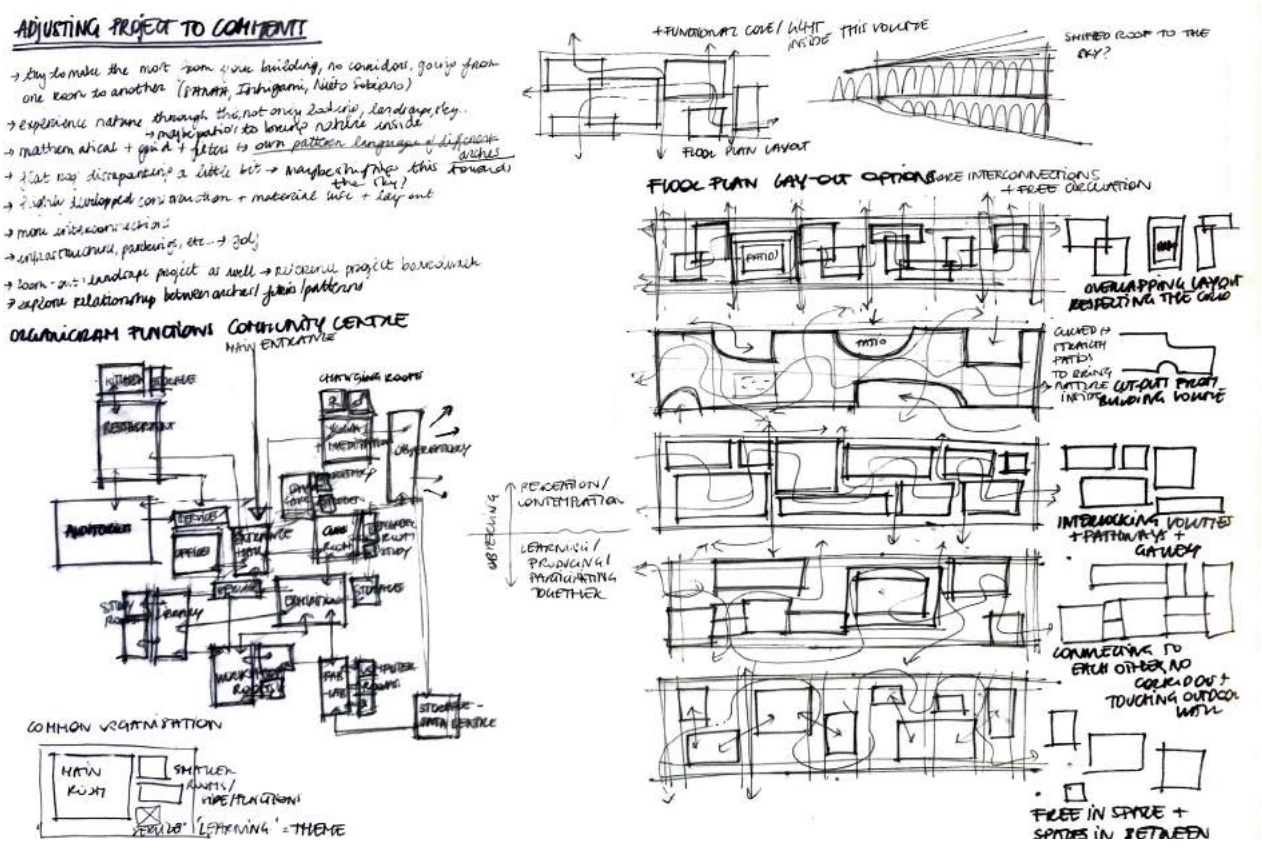
Pattern Language System community gate, own production, Bo Westerlinck



Community gate design panel, own production, Bo Westerlinck



Design sketches experiencing nature, own production, Bo Westerlinck



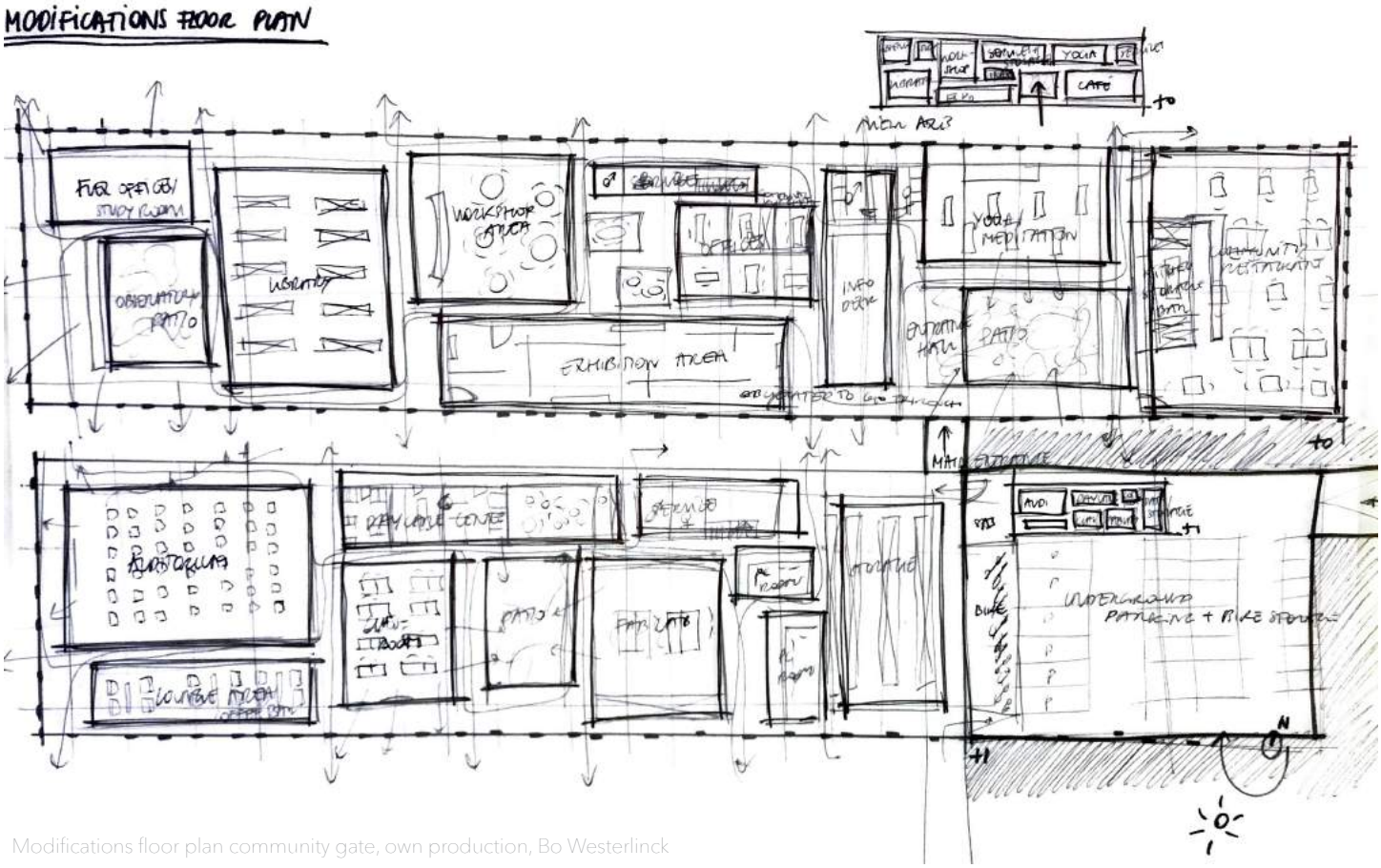
Design sketches adapting community gate, own production, Bo Westerlinck

In this design I also used a systematic approach, the building consisted of several 'slices' or pieces. In which, each time a main function was placed in a large space with three adjacent smaller spaces in which the additional functions could be placed. All around the building there was a gallery, surrounded by the beautiful nature. Sometimes the inner volume touched the outside wall of the gallery, sometimes it kept its distance. This in order to obligate people to circulate outside through the beautiful nature and to experience it more rather than being inside in this pavilion.

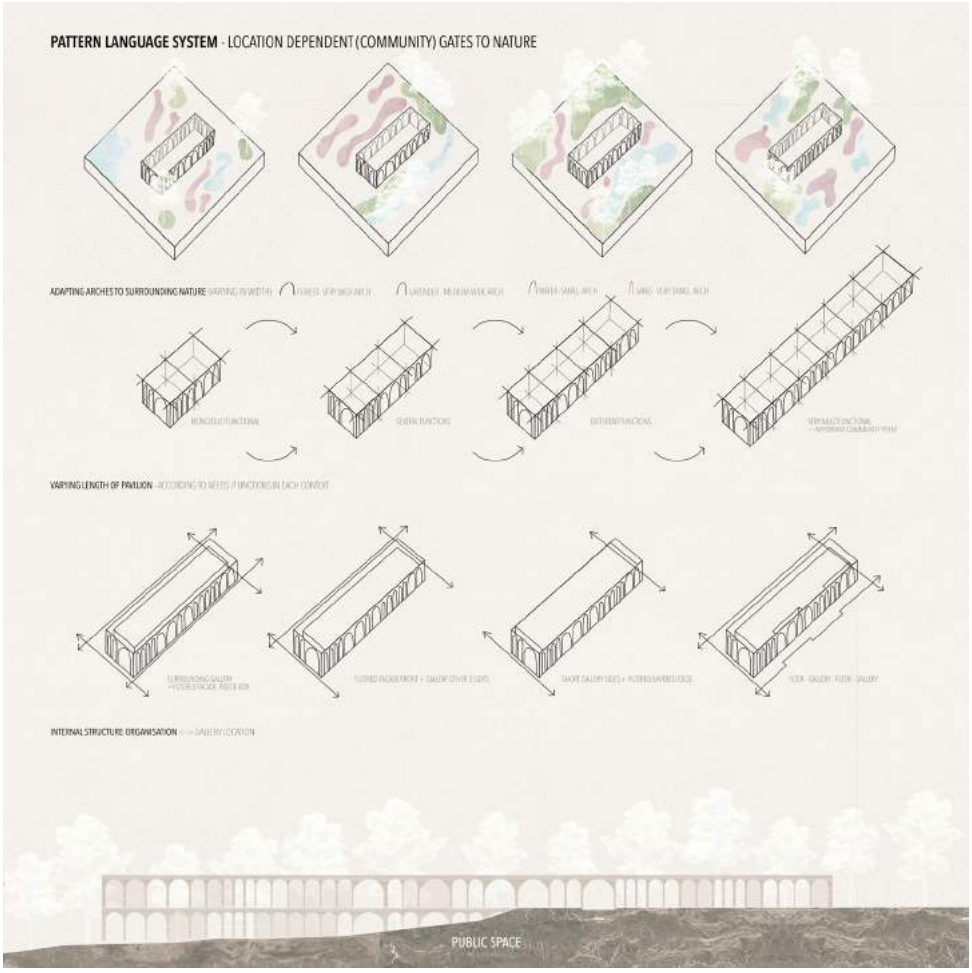
It was therefore my intention that this would function as a system of different gateways to other nature reserves, all collecting data and serving as a 'community gate'. One could choose how many disks/pieces one needed for each specific nature area, depending on the functions one wanted to bring into it or the wishes and needs of the local population. This longitudinal option I had worked out was one of the larger options, the others would probably be smaller.

As already mentioned in '2.1.2. Analysis Nature reserve - Patterns/parameters found in nature', I used the arches in this project as a direct reflection of the different types of landscapes behind them. The wider the arc, the denser the nature (e.g. dense forest), the narrower the arc, the more open the landscape behind it (e.g. drifting sands). As can be seen in previous sketches, this was an intensive search what these arches could refer to and how I could deal with this architecturally. As a result, each facade would be a unique design, both the different elevations within one building and two different buildings, the chance that the same facade would occur was very small. Finally, the relationship between the gallery and the internal organisation was also variable. In order to strengthen the play between inside and outside and to soften this border.

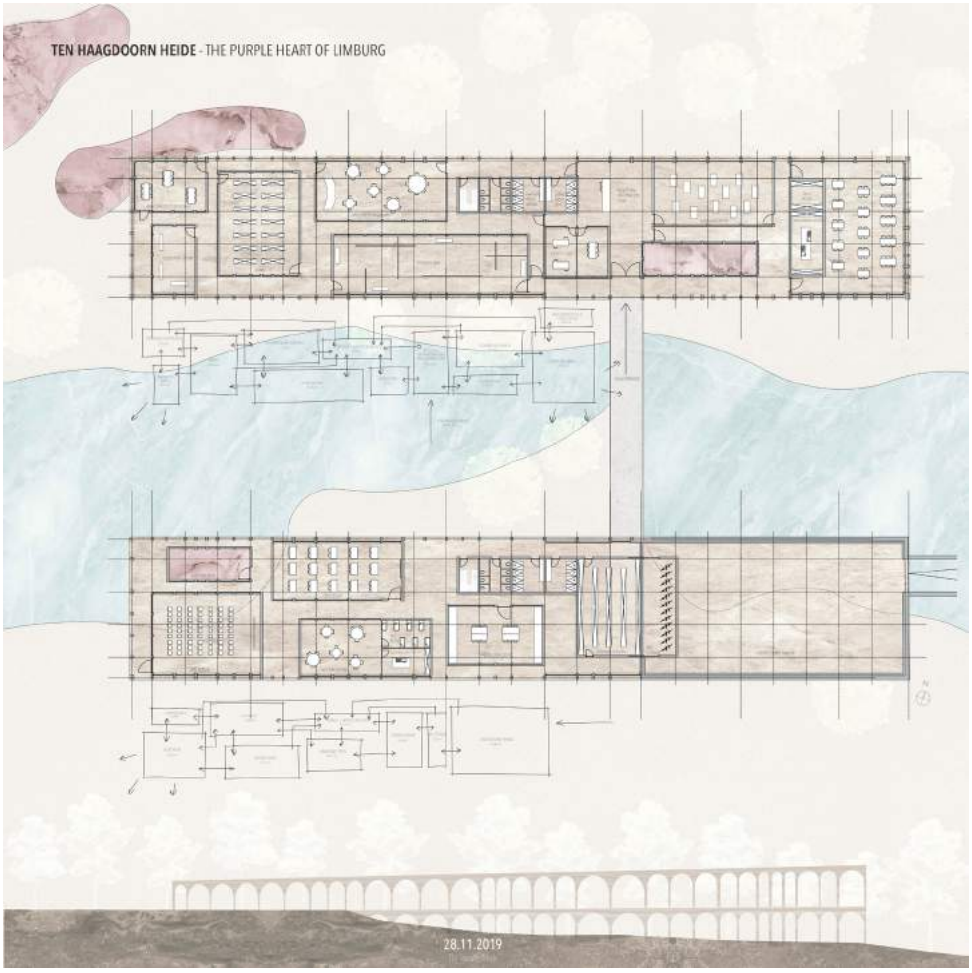
Furthermore I experimented how to deal with the internal organisation in a more free way. The rigid internal slices evolved into a composition of different spaces, inspired by Japanese architecture from e.g. SANAA, Toyo Ito, Ischigami.



Modifications floor plan community gate, own production, Bo Westerlinck



Pattern Language System community gate, own production, Bo Westerlinck



Community gate adapted design panel, own production, Bo Westerlinck

OWN MASTER PROJECT

2. IDENTIFICATION CHALLENGES

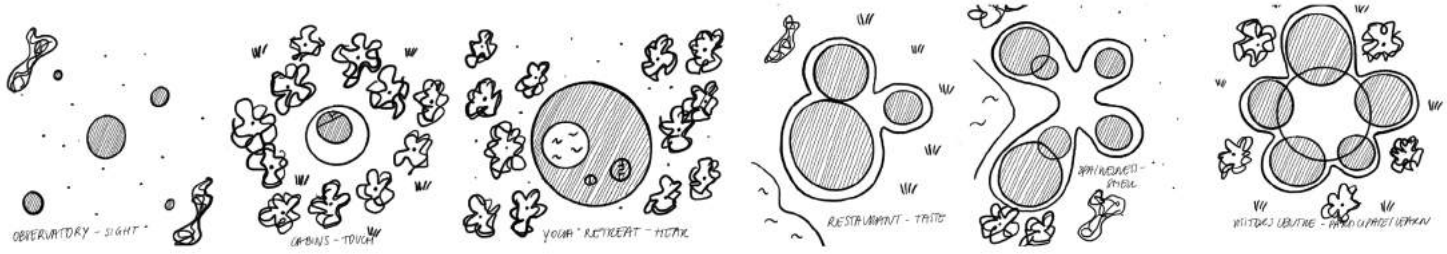
2.2. TRIAL AND ERROR

2.2.3. PAVILIONS - SPREAD FUNCTIONS EACH FOCUSSING ON A CERTAIN SENSE

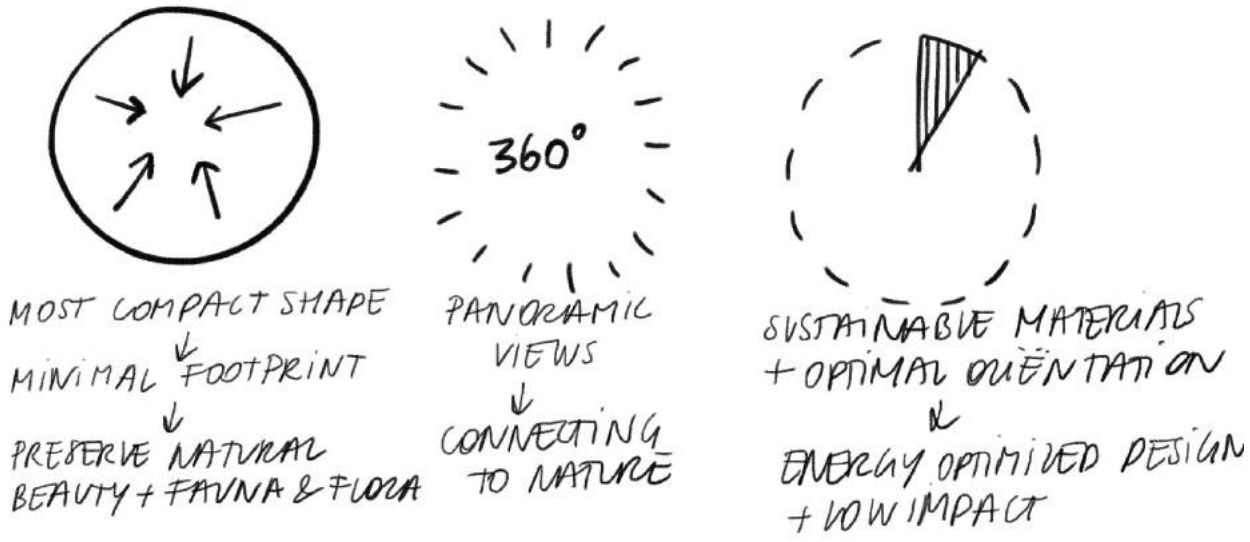
Since the experience of the nature reserve was rather limited to the occasional short walk through the gallery at the previous 'community gate' project, I chose to design smaller interventions at strategic places in this nature reserve. This translated into a number of different pavilions, each with their own specific focus on a particular sense. Moreover, people also saw and experienced the entire nature reserve when moving from one pavilion to another.

Considering that a circle is one of the most compact forms (to have a minimal impact on this valuable nature), that it provides a panoramic view and that it is very sustainable in terms of natural light, I chose to work wit circular organised architecture. Then I translated the density of the different types of landscapes into four different types of circular-organized nature. When nature was very dense, the circles were compressed and natural light was provided from within. When there were only a few isolated trees in an open space, the circles overlapped. When there were many lavender shrubs in the vicinity, the circles just touched each other. Finally, when the pavilion was in a very open area of drifting sands, for example, these circles were also spread out.

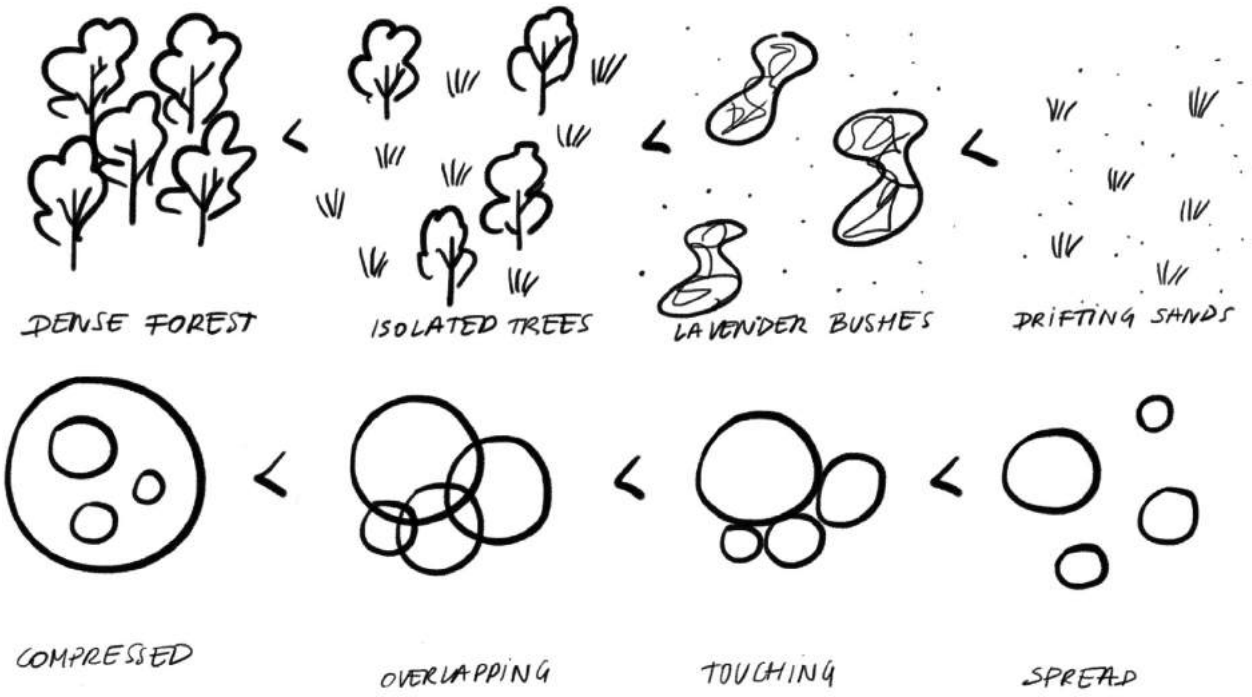
Then I applied this principle to several unique places in this nature reserve. In the middle a watchtower, which of course represented the sense 'looking'. In the dense forest I placed small cabins, where one could really be in 'touch' with nature. Then the yoga pavilion was mainly based on sounds, one could hear the rainwater that was being collected in the patio. A small restaurant represented 'tasting' and the wellness was all about scents. To this I added a visitors centre where people could learn about the area and participate in certain workshops.



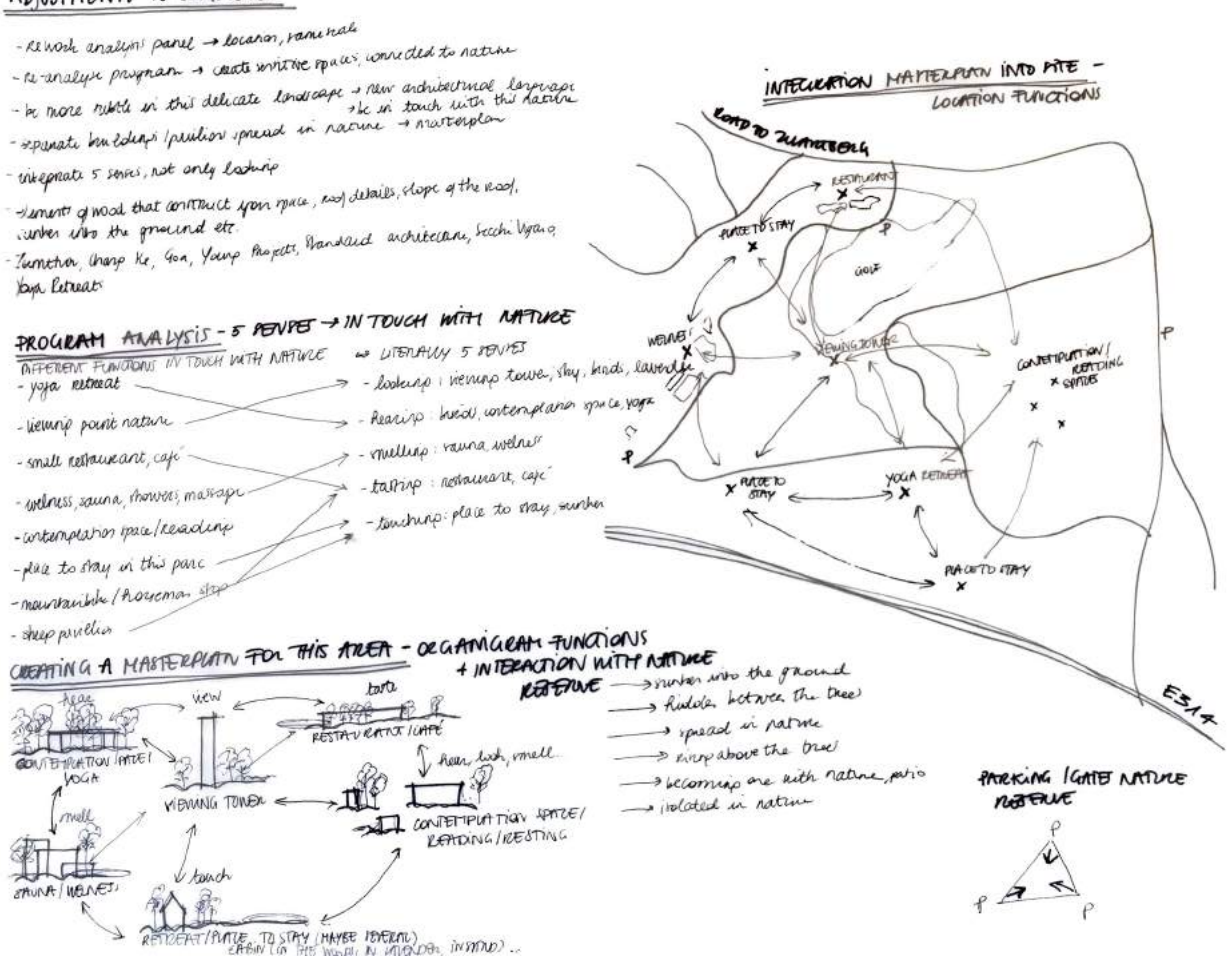
Diagrams separate pavilions, own production, Bo Westerlinck



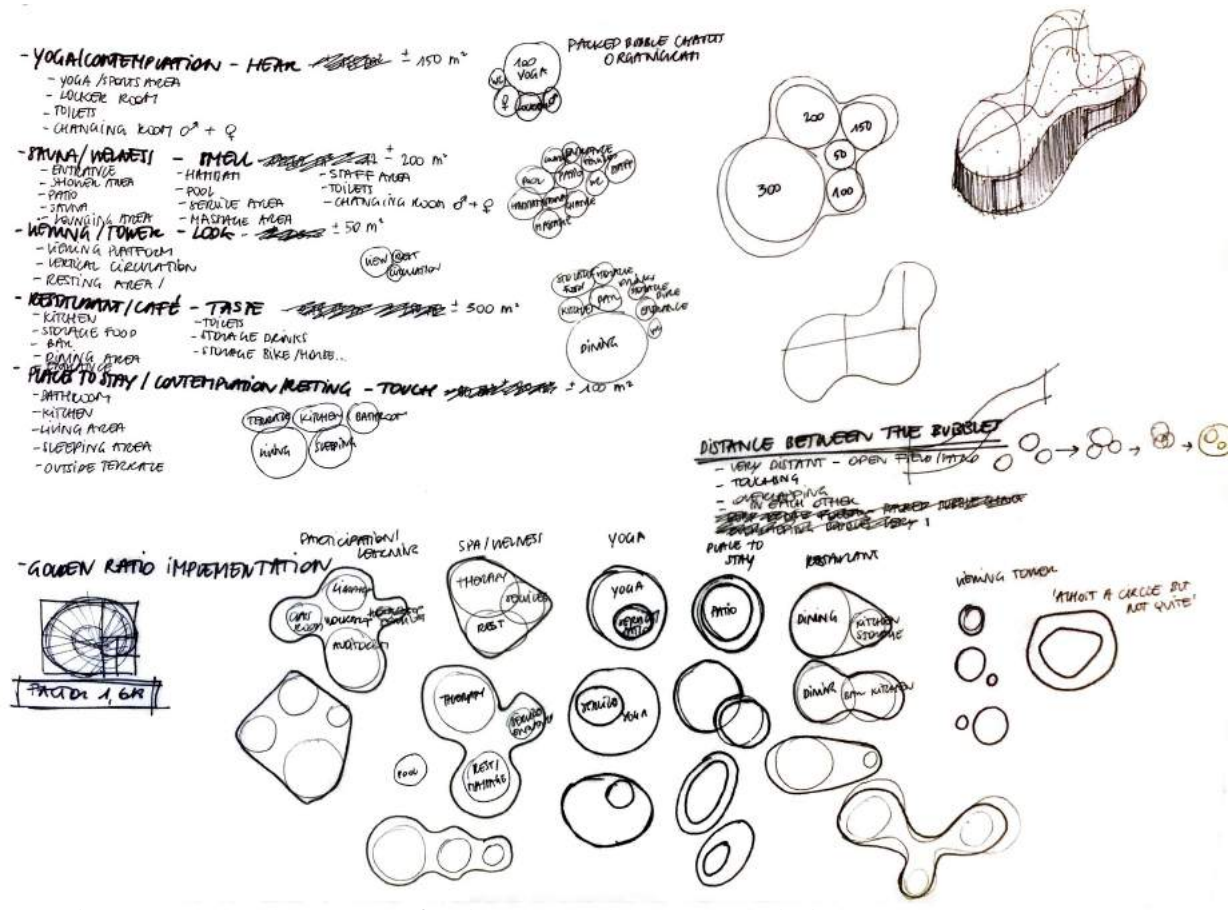
Circular organisation, own production, Bo Westerlinck



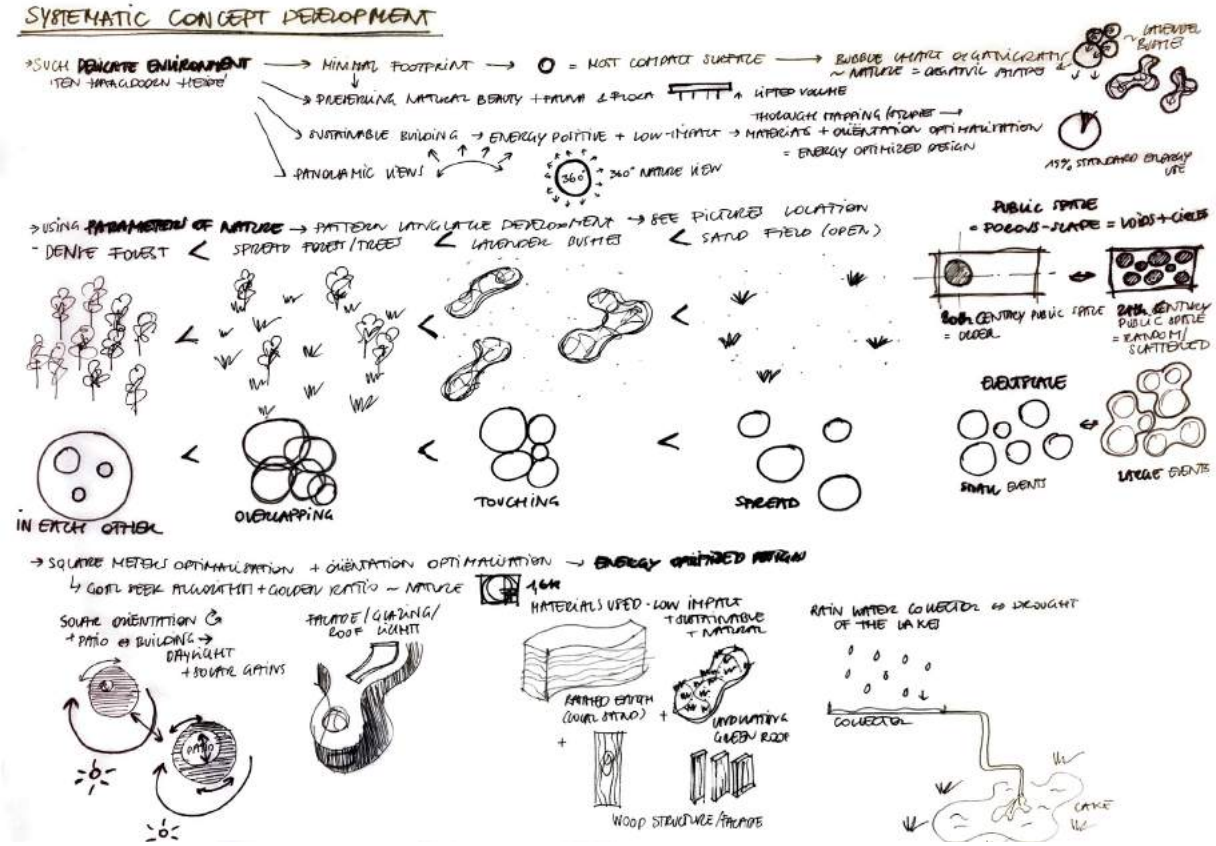
Translating density of nature to density of architecture, own production, Bo Westerlinck



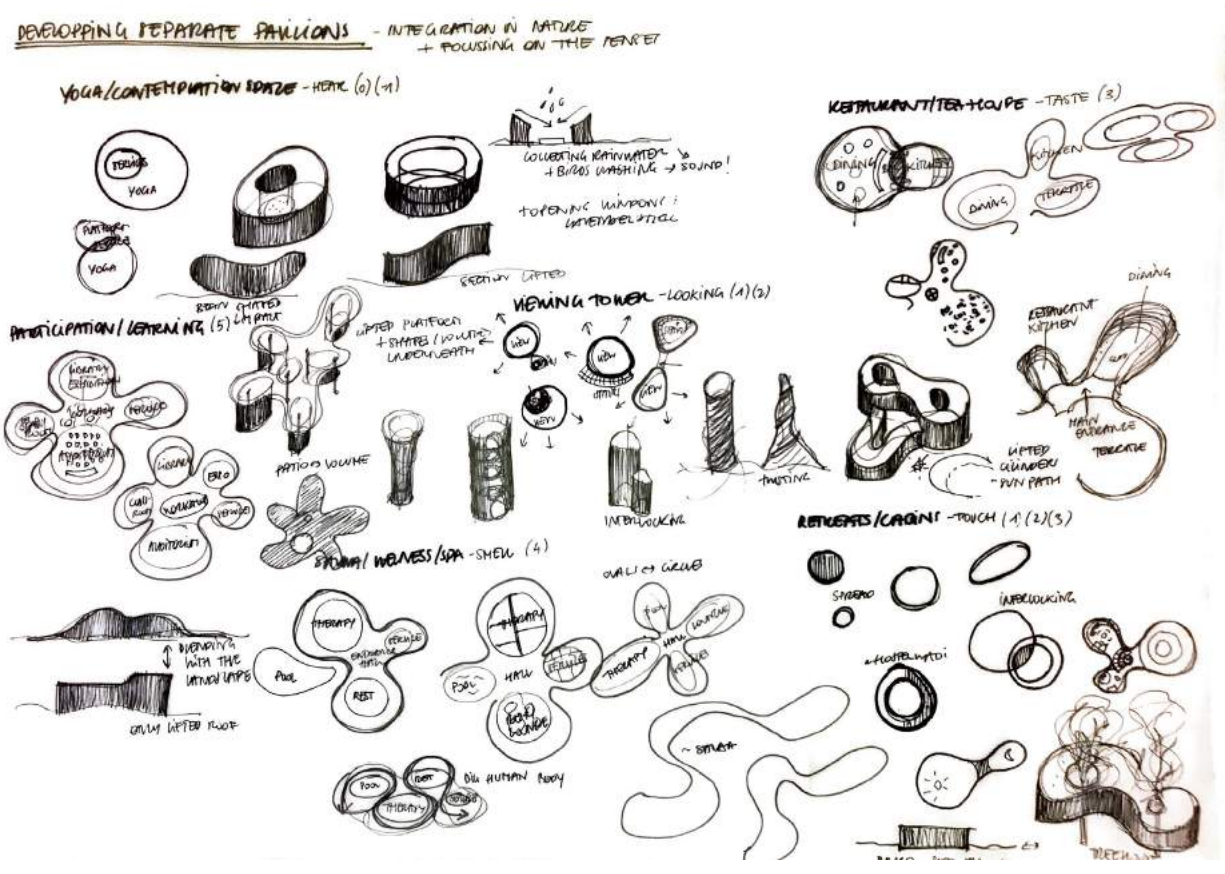
Design sketches creating a masterplan, own production, Bo Westerlinck



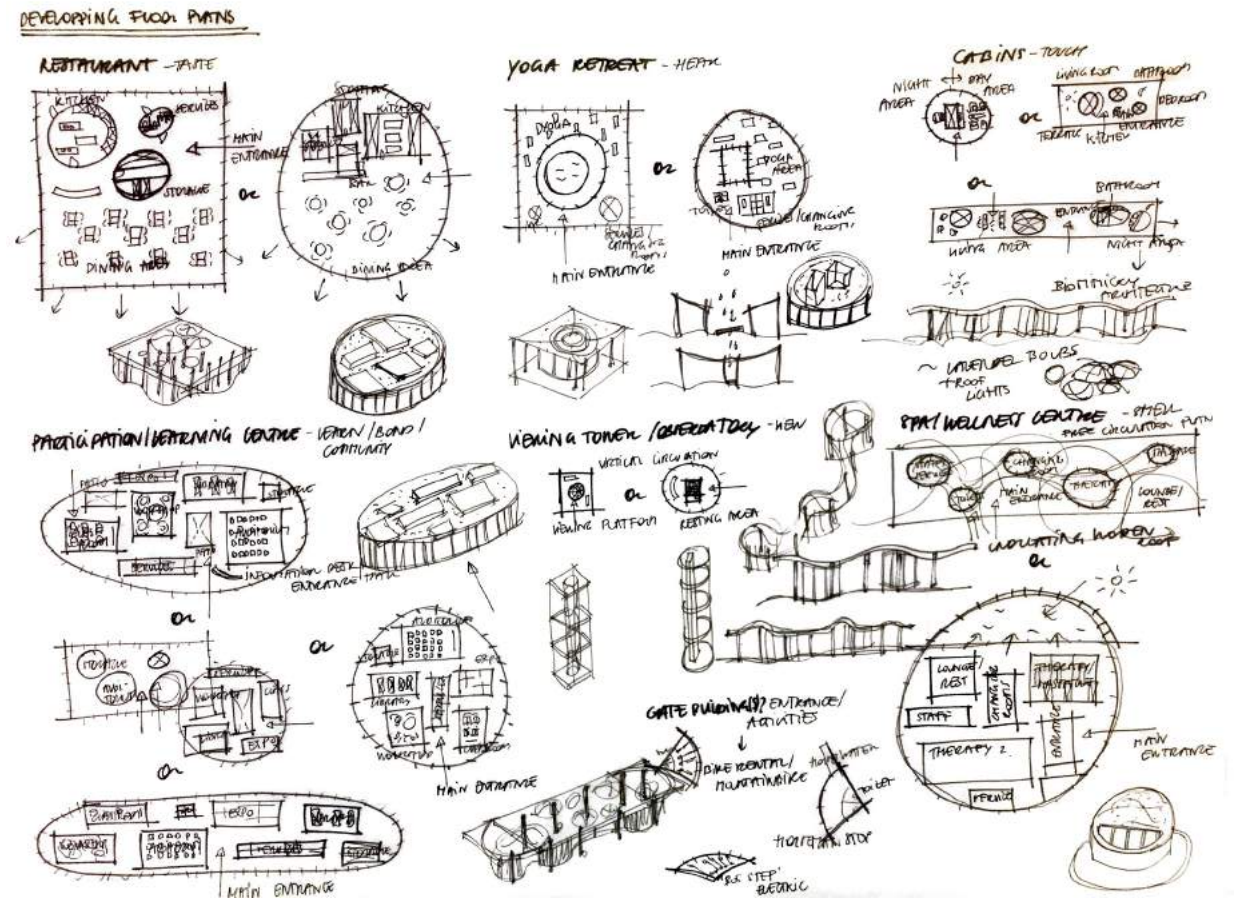
Design sketches program and organisation of pavilions, own production, Bo Westerlinck



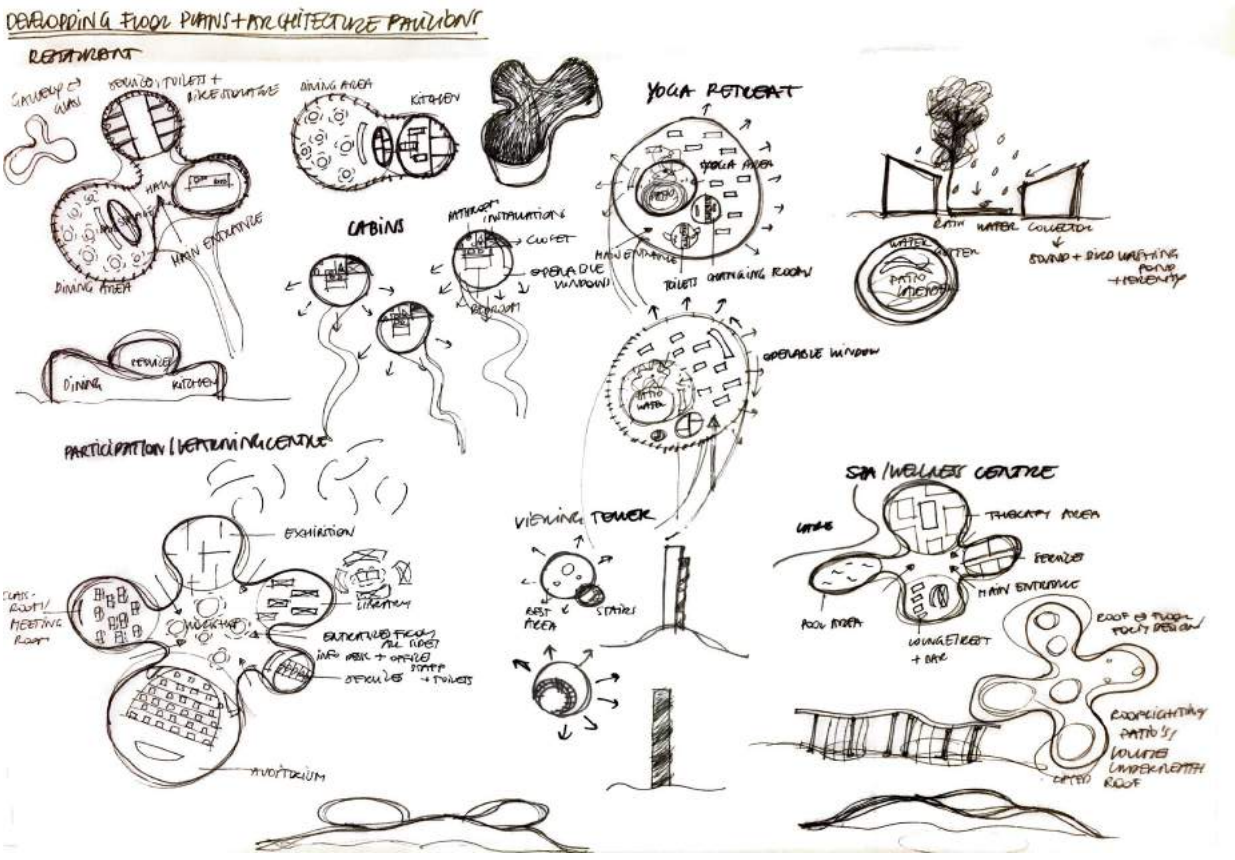
Design sketches systematic concept development, own production, Bo Westerlinck



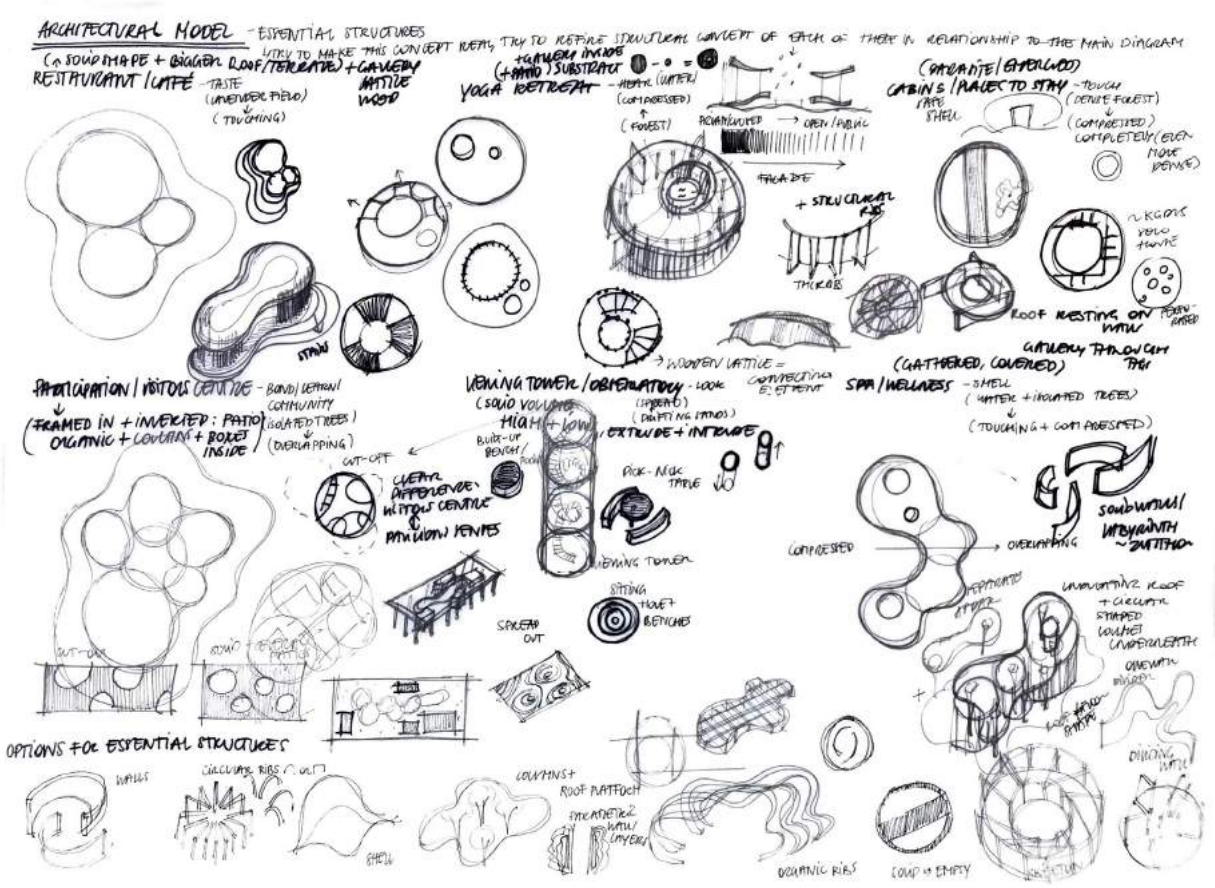
Design sketches developing separate pavilions, own production, Bo Westerlinck



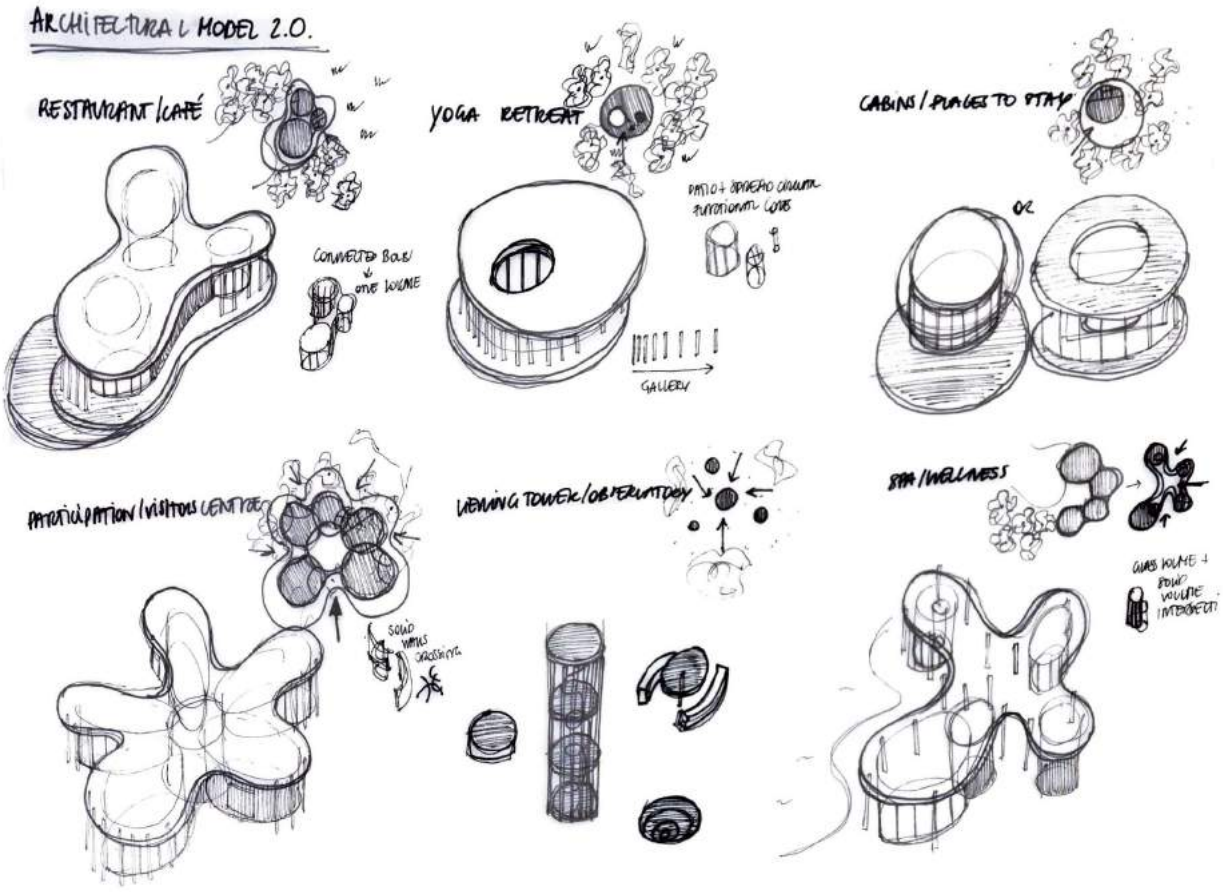
Design sketches developing floor plans, own production, Bo Westerlinck



Design sketches developing architecture pavilions, own production, Bo Westerlinck



Design sketches architectural models pavilions, own production, Bo Westerlinck



Design sketches architectural models pavilions, own production, Bo Westerlinck

OWN MASTER PROJECT

2. IDENTIFICATION CHALLENGES

2.2. TRIAL AND ERROR

2.2.4. CONNECTING THE NATURE RESERVE & CREATING AN IDENTITY

Instead of focusing only on specific areas where strategic interventions are subsequently designed, I realized during the first semester that **a global strategy for the entire nature reserve was needed which brings all the interventions together to a coherent landscape and architecture project.** In the previous sketches/ projects I mainly focused on the part of the nature reserve that was situated at the North of the highway E314, namely 'Ten Haagdoorn Heide'. However, since the nature reserve actually runs further south of the highway, which is also called 'De Teut'.

In order to develop an appropriate global strategy for this, I expanded my research to the entire area, so 'Ten Haagdoorn Heide' and 'De Teut'. This both in terms of hydro-geography, as well as the different types of nature that were present, and all the walking, cycling, mountain biking and equestrian routes that are present. But also the characteristic vegetation, tree species and which animals have their natural habitat here. **Subsequently I developed an appropriate strategy for each of these points of analysis that together make up the global project idea.**

First and foremost, hydro-geography; I want to promote the biodiversity of this cultural landscape, by restoring the water balance by providing more infiltration possibilities along the two streams, 'Laambeek' and 'Huttebeek' situated between the fingers of the topography 'Kempisch Plateau'. And by creating recreational possibilities inside this nature reserve, in the most respectful way to this nature.

Next, I want to promote the natural strengths of this beautiful landscape and highlight them to make people more aware of the beauty of this area. In addition, accessibility is also increased by introducing a floating wooden path into the area, connecting all the interventions. In addition to the strategic interventions along this path, the path itself can also be transformed into a resting place, bird watching, a place to stretch for a while, etc.

Finally, the readability of the landscape and its coherence must also be restored. By creating readable gates at the edges of it and by connecting the two separated parts back to each other, like before the highway divided this into two parts. If we could connect these two parts with an ecoduct this would be an enormous added value for the whole area and the many species that settle here.

So in short, I want to let nature thrive there, and bring people closer to this nature, to enjoy it in a very respectful way. Nowadays everyone is busy with all kinds of activities, and sometimes we forget the most important and beautiful things in life such as enjoying each other (friendship and love) and the magnificent nature around us.

OWN MASTER PROJECT

2. IDENTIFICATION CHALLENGES

2.3. USING DISCUSSED TECHNIQUES

2.3.1. MISSING PATTERN IN ANALYSED SYSTEM OF COLLECTIVITY & NATURE

During the urban analysis of the area Houthalen-Helchteren, we've created our own patterns to analyse the system of collectivity and nature. Doing this helped us to understand where the missing links were, both on a local scale and on the bigger scale. From this analysis we could conclude that the nature reserves lack a clear identity and gateway/access point or subtle infrastructure that facilitates the visit and experience of these areas.

Personally, it was immediately clear to me that I wanted to do something with the beautiful nature that is present in Houthalen-Helchteren, connecting the people to each other and bringing them back closer to the nature simultaneously. Moreover, the interviews also showed us that the citizens prefer to meet each other in a natural and peaceful area rather than going to the city centre. After this was decided, the research started how I could design these strategic interventions.

2.3.2. CREATING MY OWN PATTERN LANGUAGE/USING A SYSTEMATIC APPROACH

As already explained in 2.1.2., I've started each of the previous explained design concepts with a systematic strategy or pattern system in mind. This of course has a big influence on the way you think as a designer and the designs that are created within this mindset. This systematic approach makes it a very flexible medium, in which adjustments can be made quickly or a multitude of options can be tested out. However, the possibilities are endless, so it is very important to not get lost in this and to carefully examine the things you want to base your pattern language on.

Since this time I am in a natural context and have few other points of reference besides nature itself and the patterns that can be recognized in it, I chose to identify patterns in it and base myself on them architecturally. This in order to connect and blend into the existing environment as well as possible.

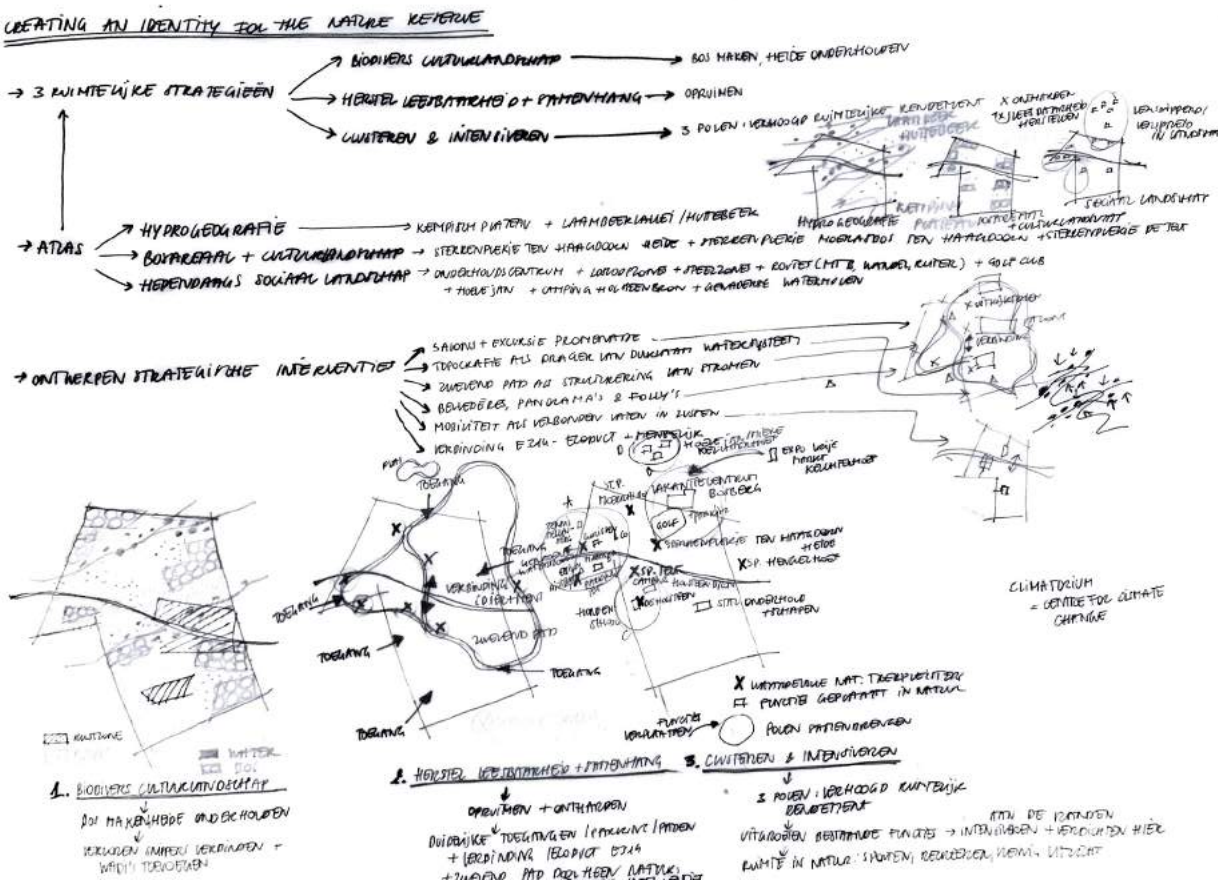
2.3.3. ADAPTING PATTERN TO LOCAL CONDITIONS/NEEDS OF THE FUTURE USER

After choosing different project locations within this nature reserve that are clearly different from each other, I always applied my principle to the direct environment and to the function/needs that were linked to it. This resulted in a family of buildings, which were all slightly different but also clearly resembled each other.

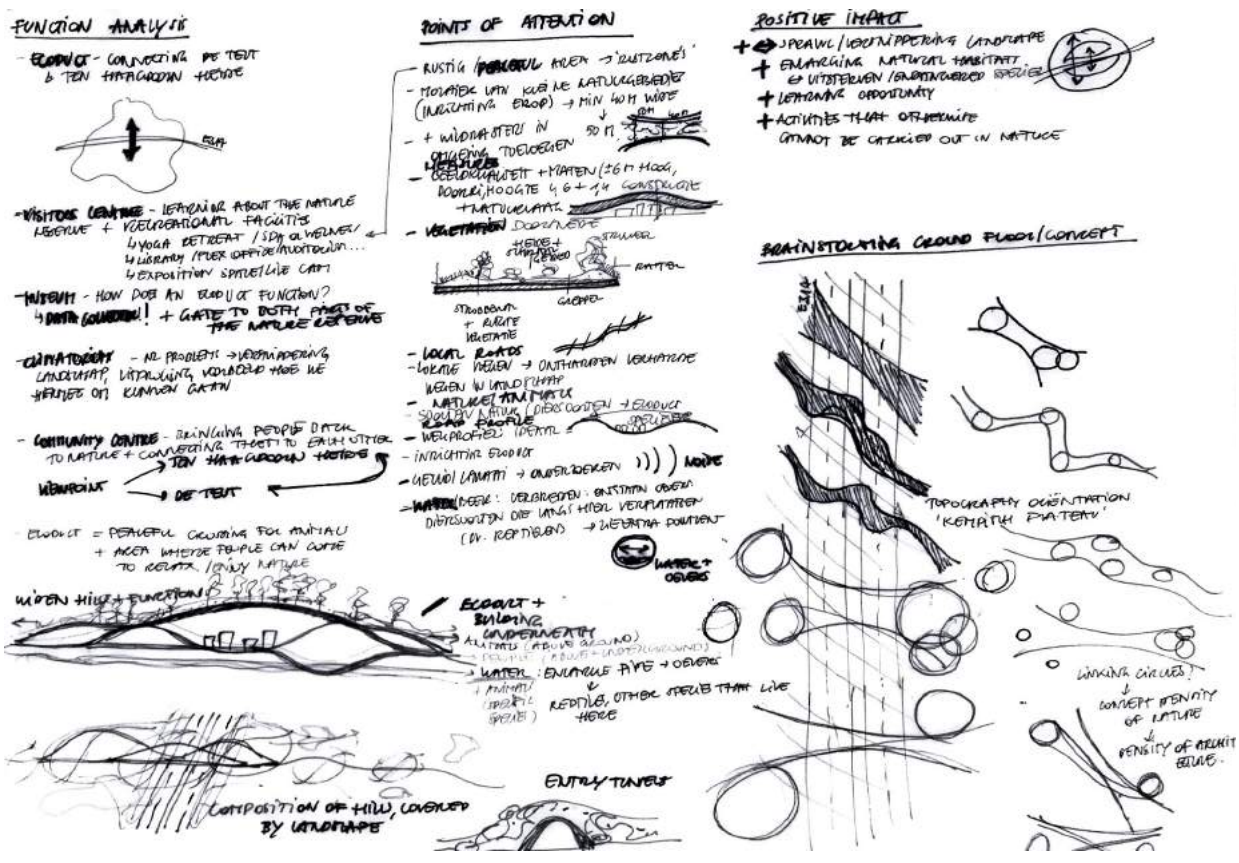
Again one has to take care that the variants remain unique enough for each place. This systematic approach does provide a certain kind of coherence, but still the experience has to be tailored specifically to each place in the landscape, each with its own characteristics. This exactly is the challenge within this project, how do you deal with this systematic approach in a very tactile and precise way, to integrate small interventions in strategic places into the landscape whose influence is greater than the intervention.

2.3.4. PARAMETRIC MODELLING TESTING/ GENERATING ALGORITHM IN GRASSHOPPER

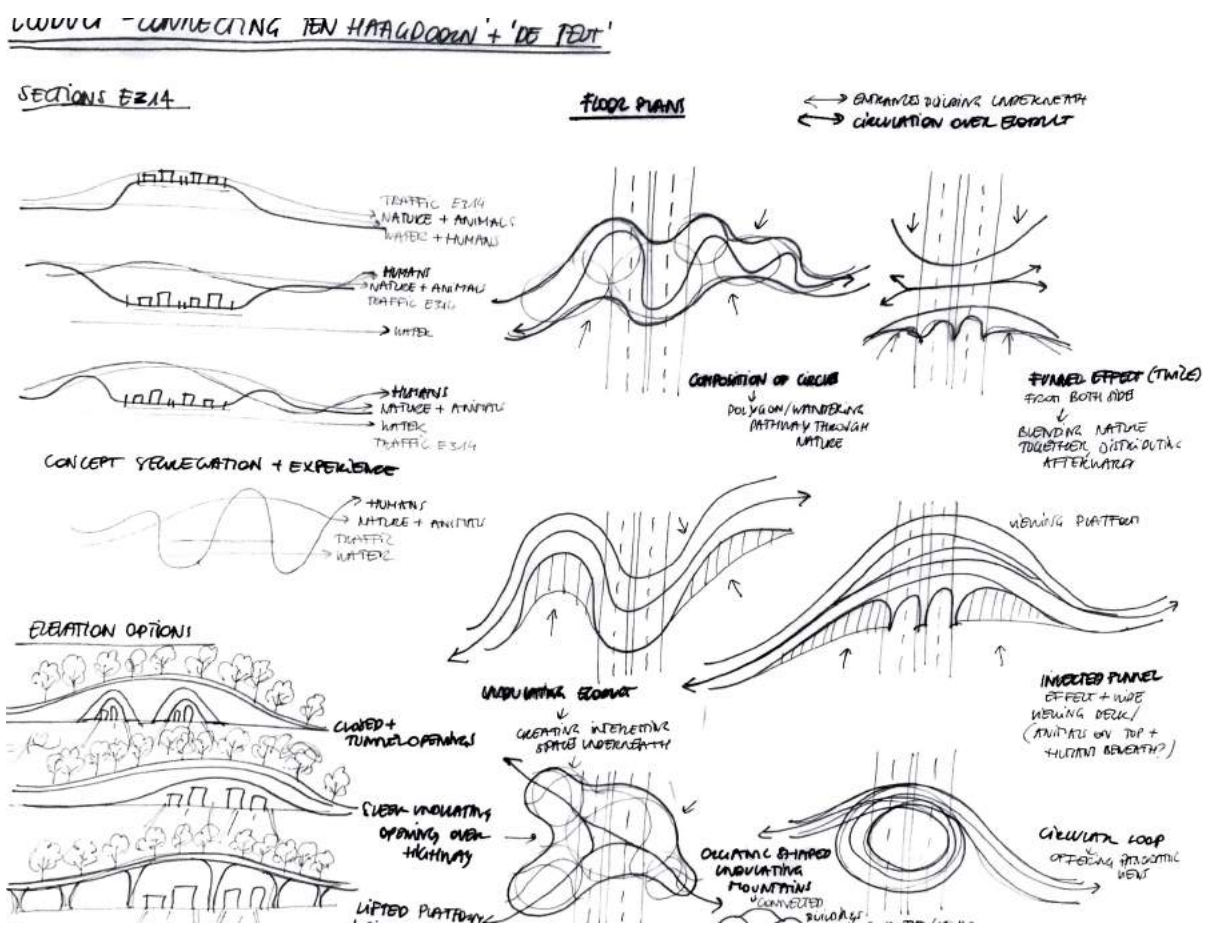
As I explained in '2.2.1. Hybrid Building', I also experimented with this technological aspect of parametricism. I designed an algorithm which allowed me to experiment with different layers of cubes, different numbers of cubes on each layer and different organisation of those cubes by sliding. But considering the availability of time and possibilities within this master project, I chose to focus myself on identifying the main patterns of this nature reserve, creating an overall design strategy with a few strategic interventions. Thus I was more interested in this social and formal experiment I talked about in the chapter Parametricism. But this technological experiment is something that is definitely possible to play with, I will do this in my further career as a designer.



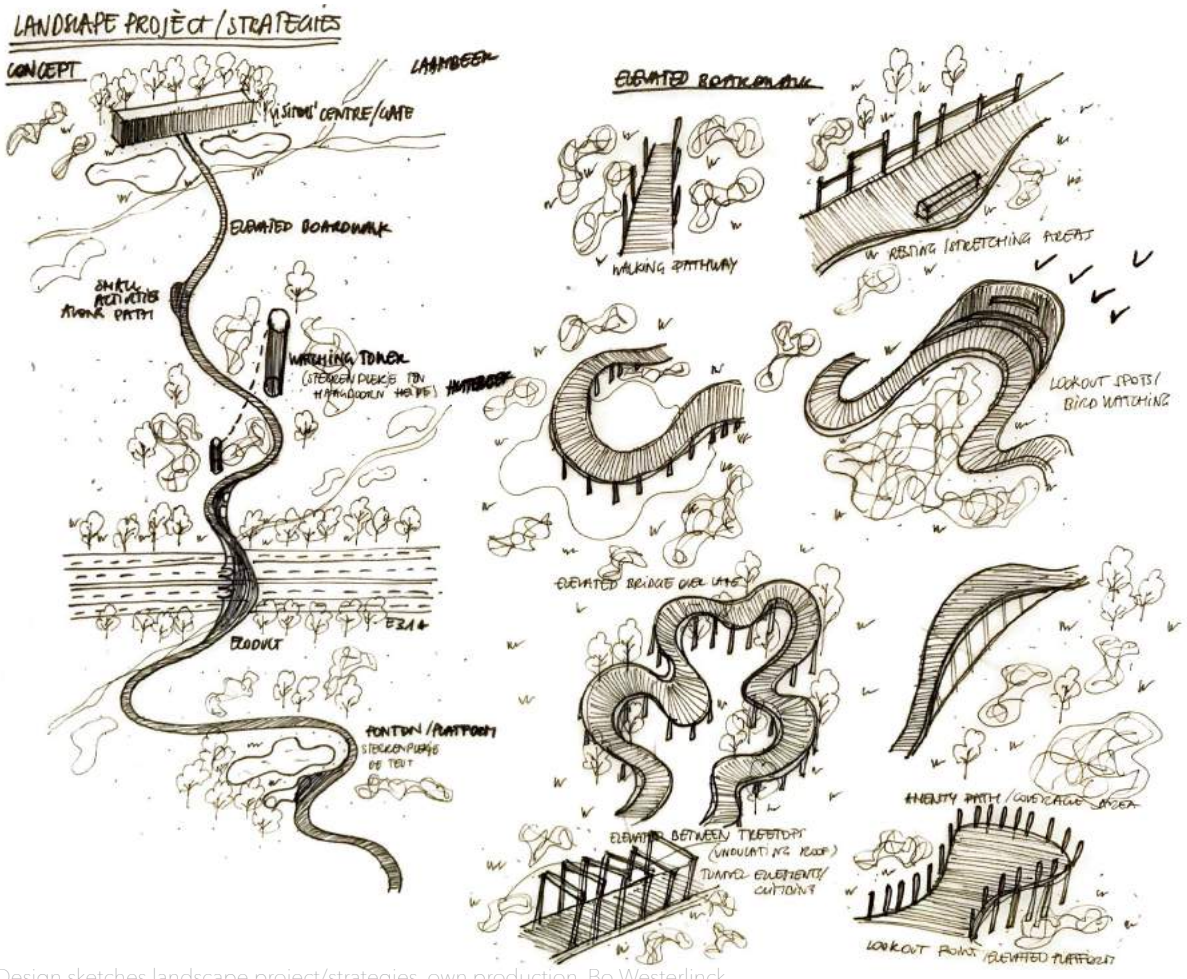
Design sketches creating an identity for the nature reserve, own production, Bo Westerlinck



Design sketches function analysis, own production, Bo Westerlinck



Design sketches ecoduct, own production, Bo Westerlinck



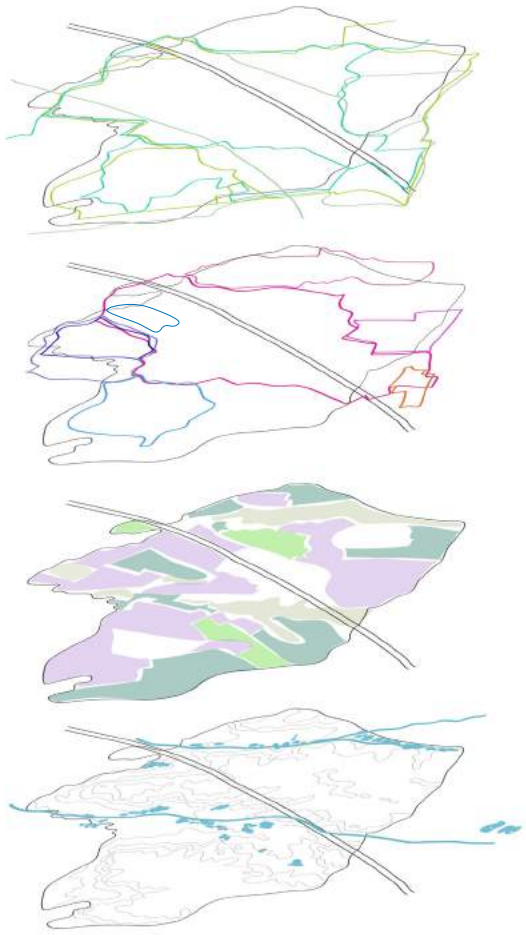
Design sketches landscape project/strategies, own production, Bo Westerlinck

OTHER PATHWAYS
- EQUESTRIAN
- MOUNTAINBIKE
- BICYCLE

WALKING ROUTES
- TEN HAAGDOORN (4,3 KM)
- TEN HAAGDOORN (5, 3 KM)
- TEN HAAGDOORN & DE TEUT (13,1 KM)
- DE TEUT (3,7 KM)
- DE TEUT (4,9 KM)
- DE TEUT (5,1 KM)
- DE TEUT (5,3 KM)
- LEARNING PATH HENGELHOEF

DIFFERENT TYPES OF NATURE
- HEATHER
- FOREST
- GRASS
- SWAMP
- RESTING AREAS

HYDROGEOGRAPHY
- TOPOGRAPHY 'KEMPISCH PLATEAU'
- LAAMBEEKVALLEI
- HUTTEBEEKVALLEI



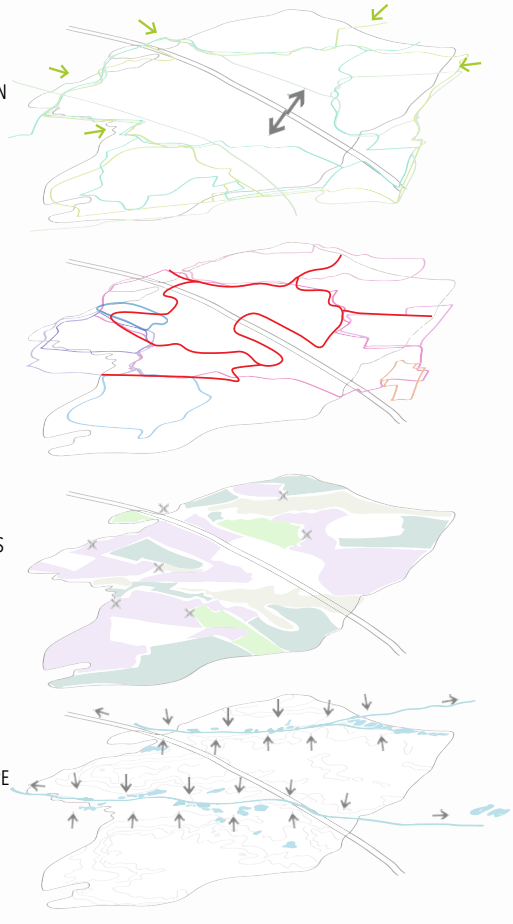
Research atlas panel, own production, Bo Westerlinck

>RESTORE READABILITY & COHESION
- COMPREHENSIVE GATES (+PARKING FACILITIES)
- CONNECTION E314 - ECODUCT

>INCREASING ACCESBILITY
- FLOATING PATHWAY FOR HIKERS, HORSEMEN, (MOUNTAIN)BIKERS

> PROMOTING NATURAL STRENGHTS
- 'STERRENPLEKJES'

> BIODIVERSE CULTURAL LANDSCAPE
- ADDING FOREST
- WATER MANAGEMENT



Design strategy panel, own production, Bo Westerlinck

FLOATING PATH · AS A GUIDING LINE THROUGHOUT THE RESERVE + NATURAL STRENGHTS

WATCHTOWER · OVERLOOKING THE BEAUTIFUL NATURE RESERVE

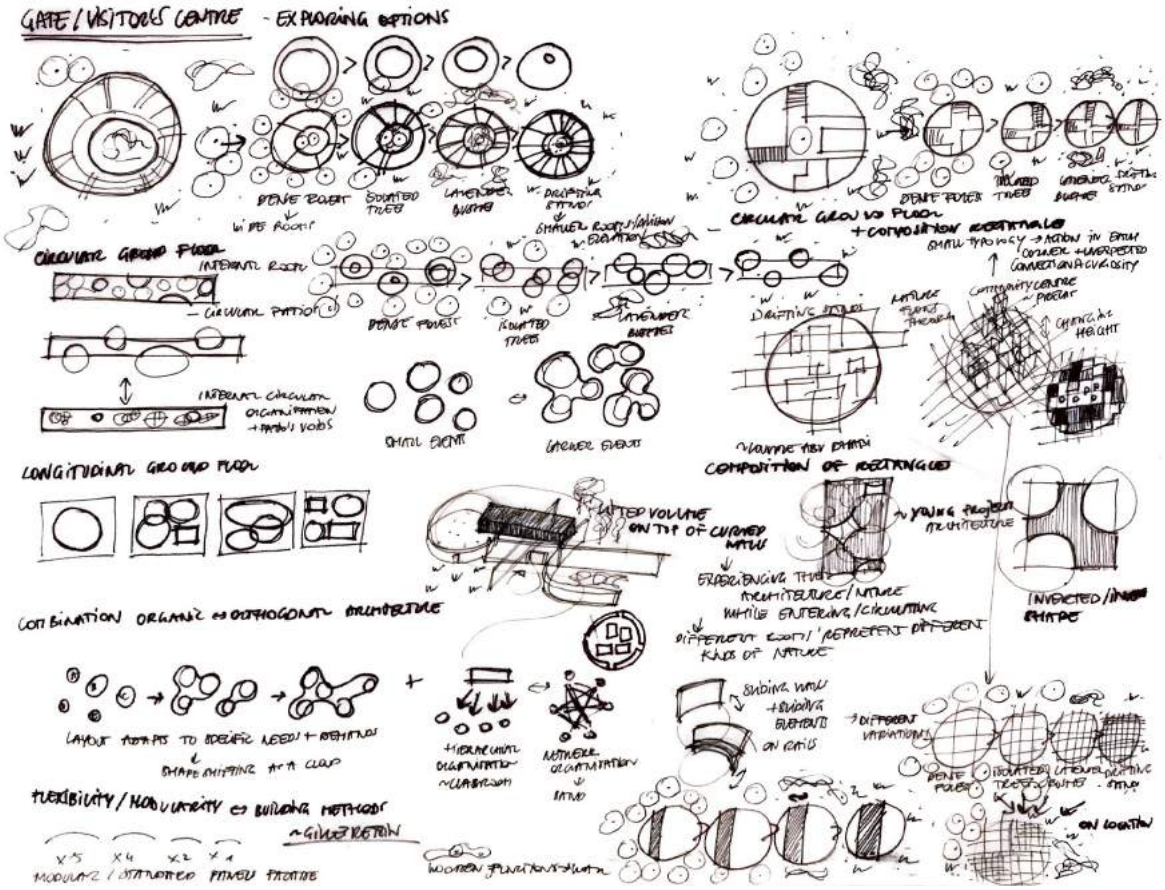
SUSTAINABLE RECREATION · IN TOUCH WITH NATURE AND EACH OTHER

ECODUCT · CONNECTING TEN HAAGDOORN & DE TEUT WITH EACH OTHER

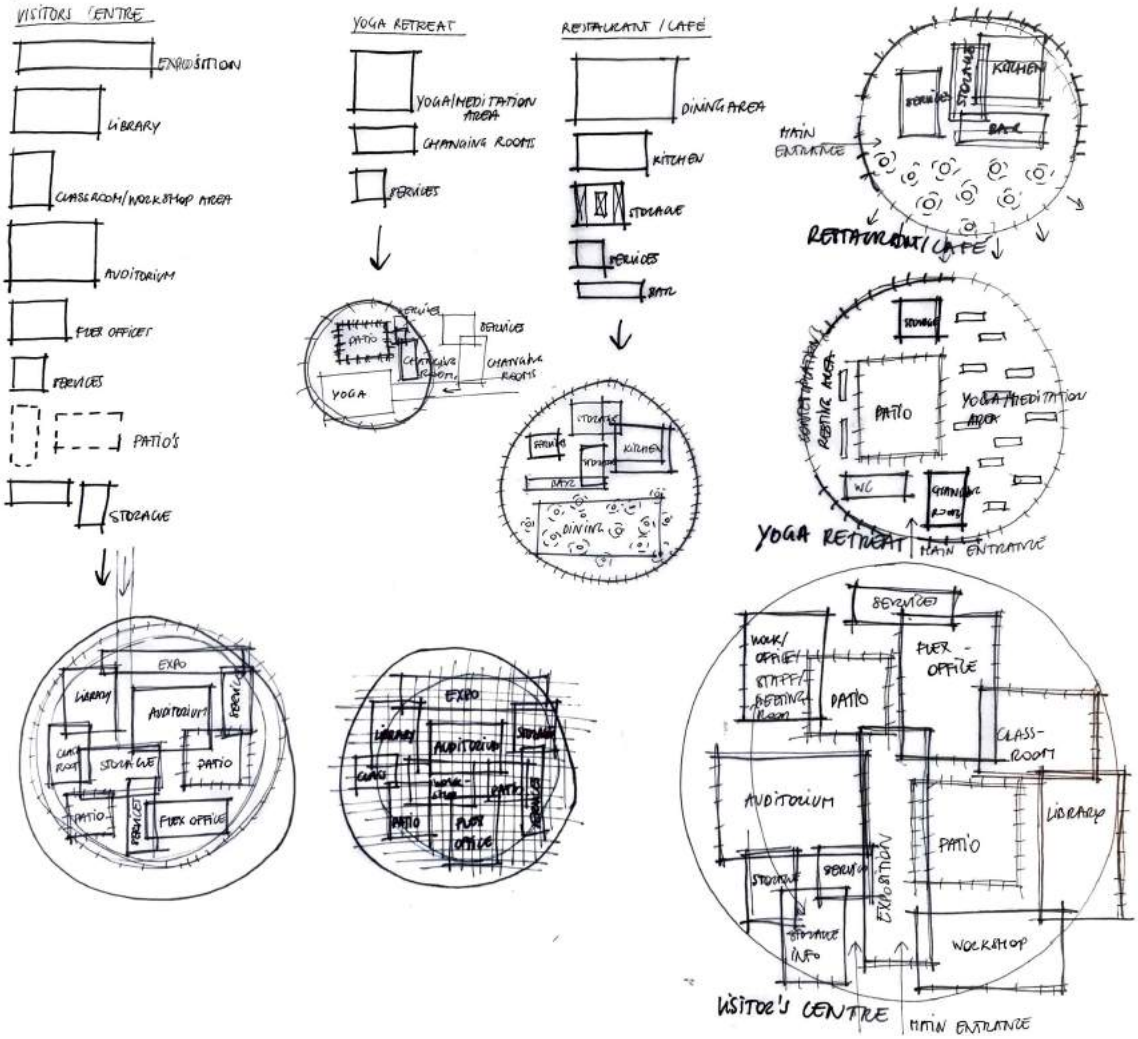
Desianina strateaic interventions

Designing strategic interventions panel, own production, Bo Westerlinck

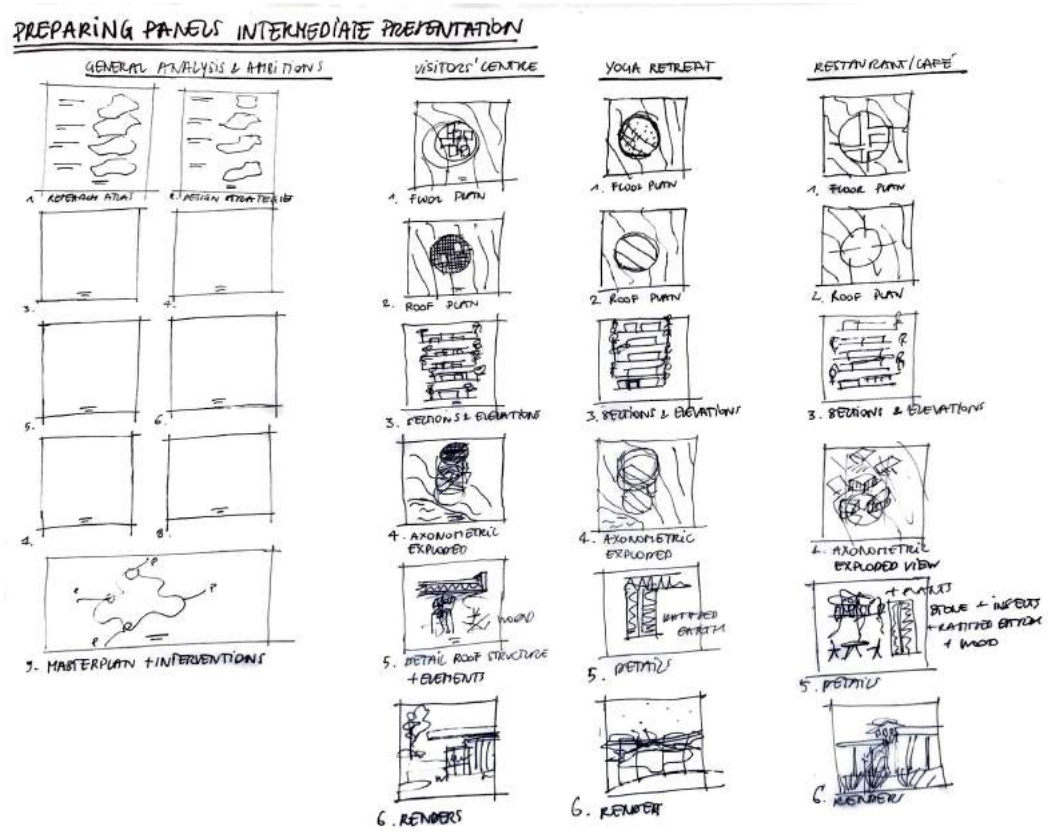
Designing the master plan of the nature reserve, own production, Bo Westerlinck



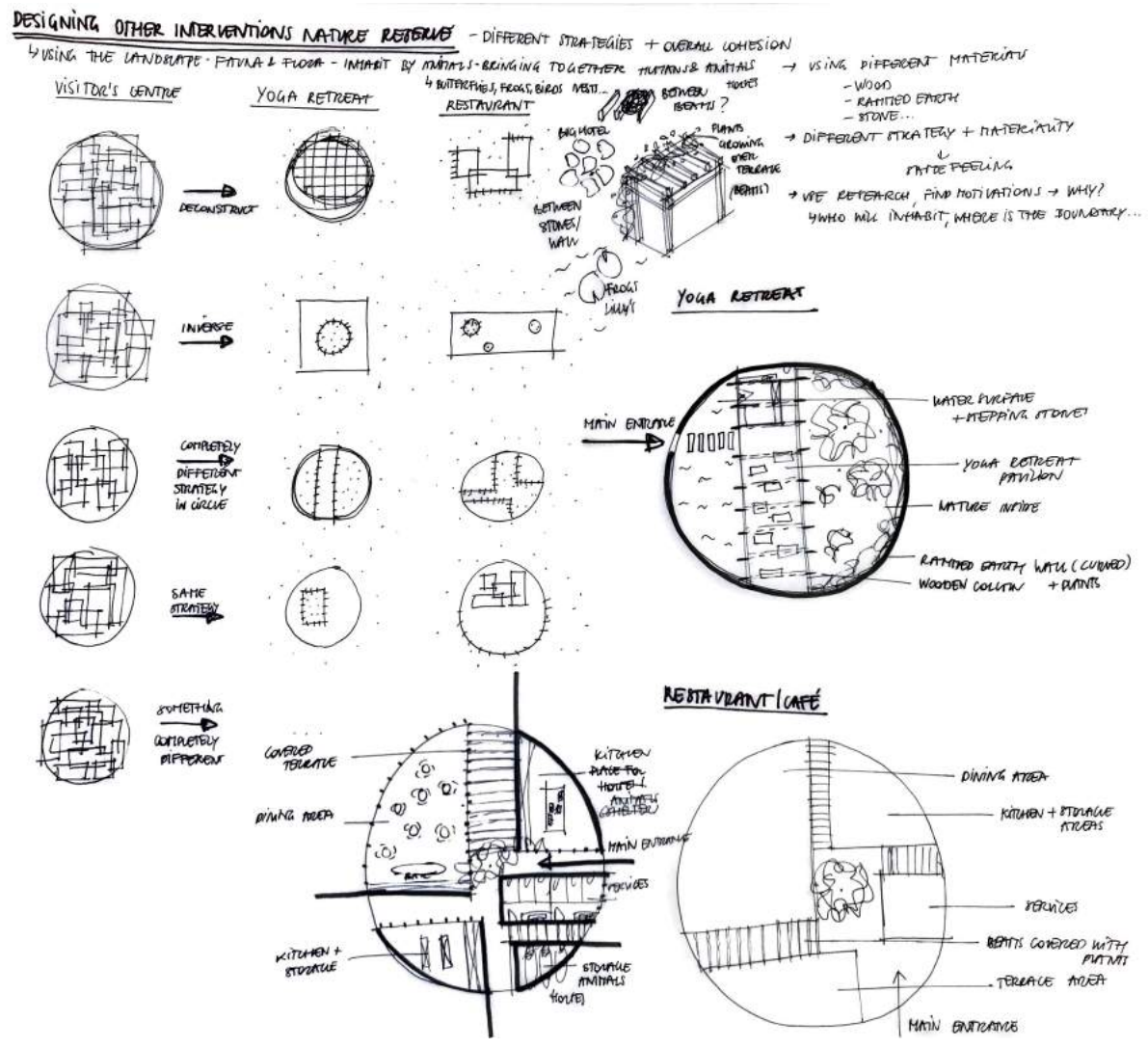
Design sketches exploring options for visitors centre, own production, Bo Westerlinck



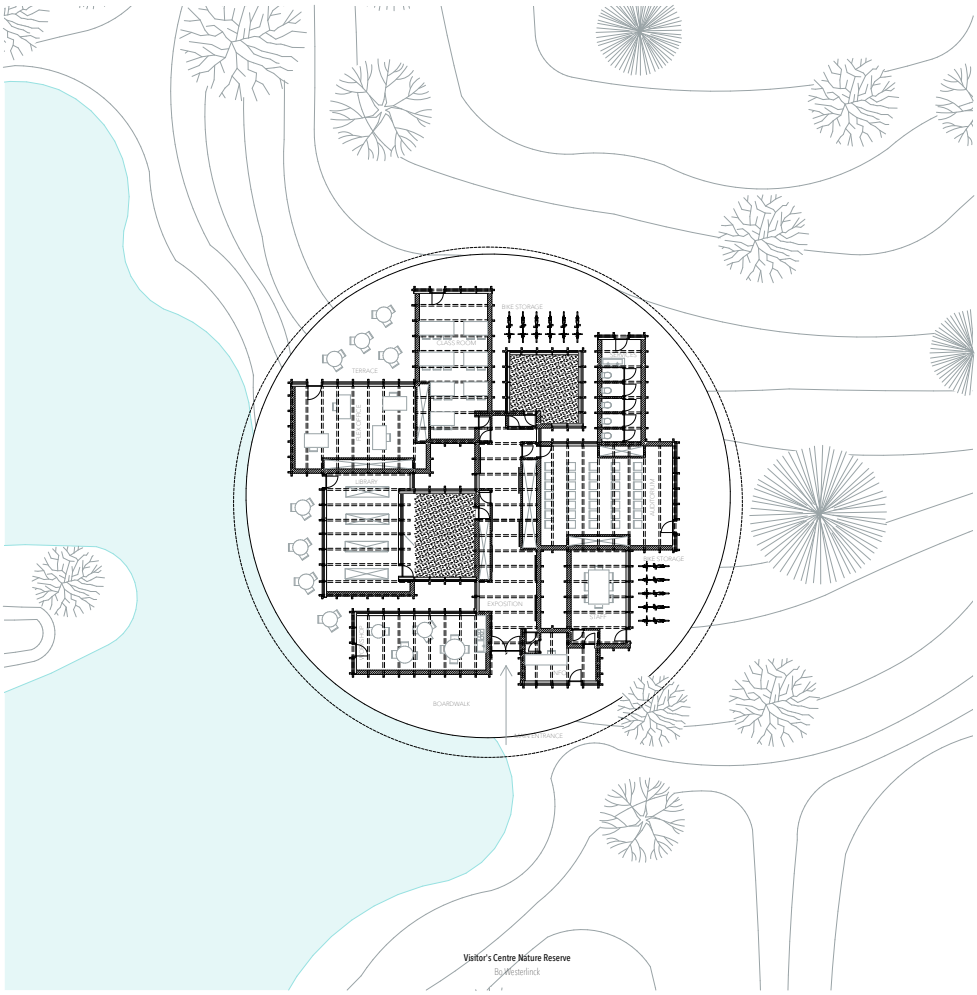
Design sketches programmatic analysis, own production, Bo Westerlinck



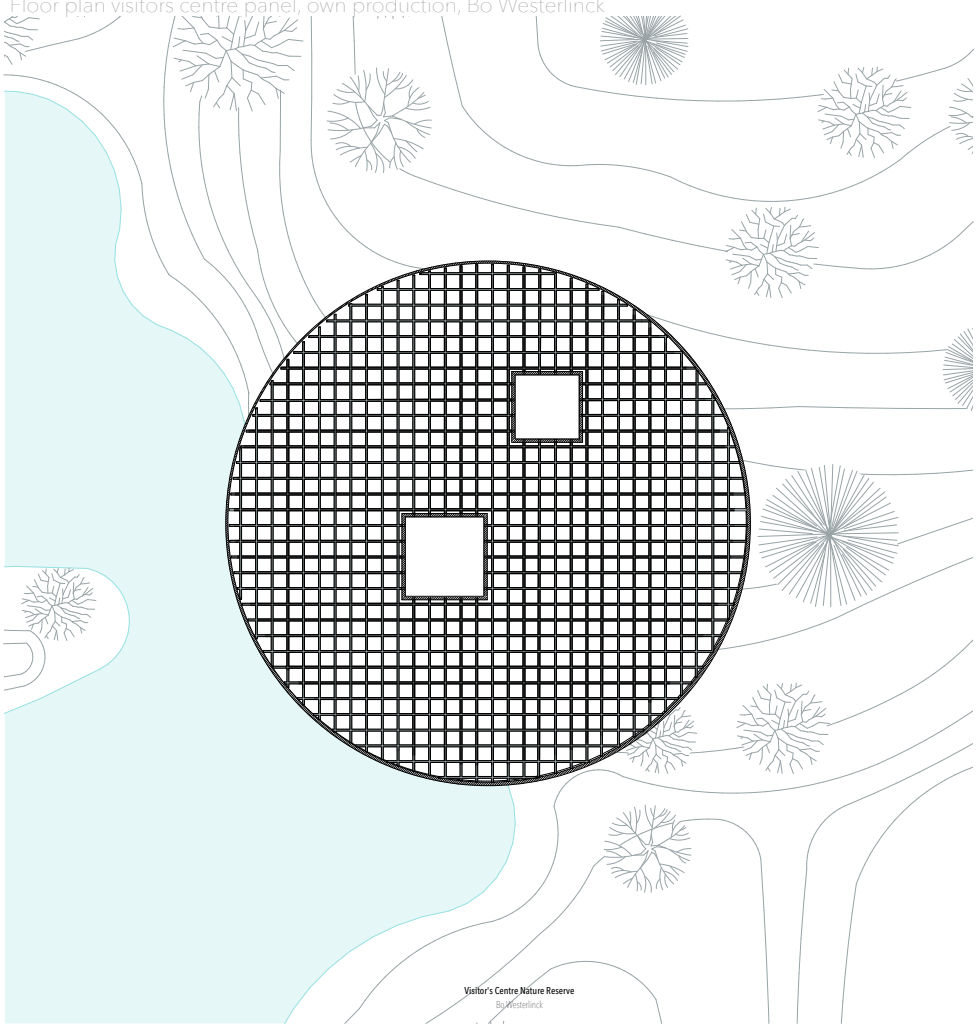
Design sketches preparing presentation panels, own production, Bo Westerlinck



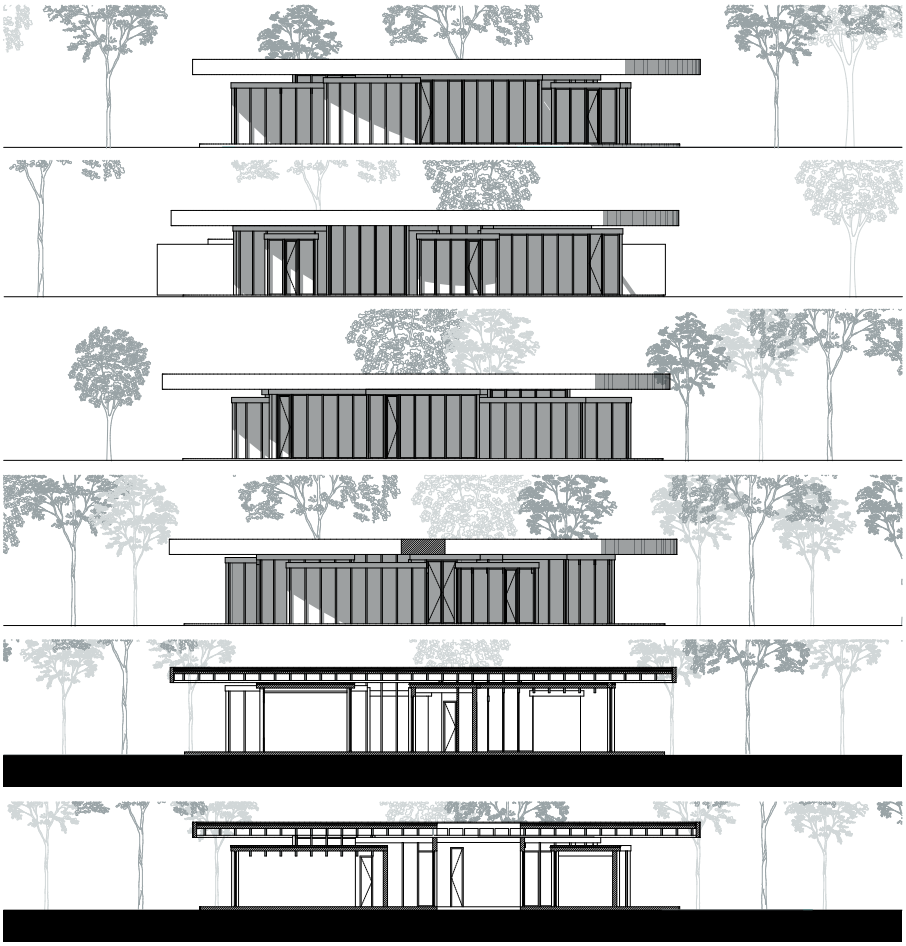
Design sketches other interventions nature reserve, own production, Bo Westerlinck



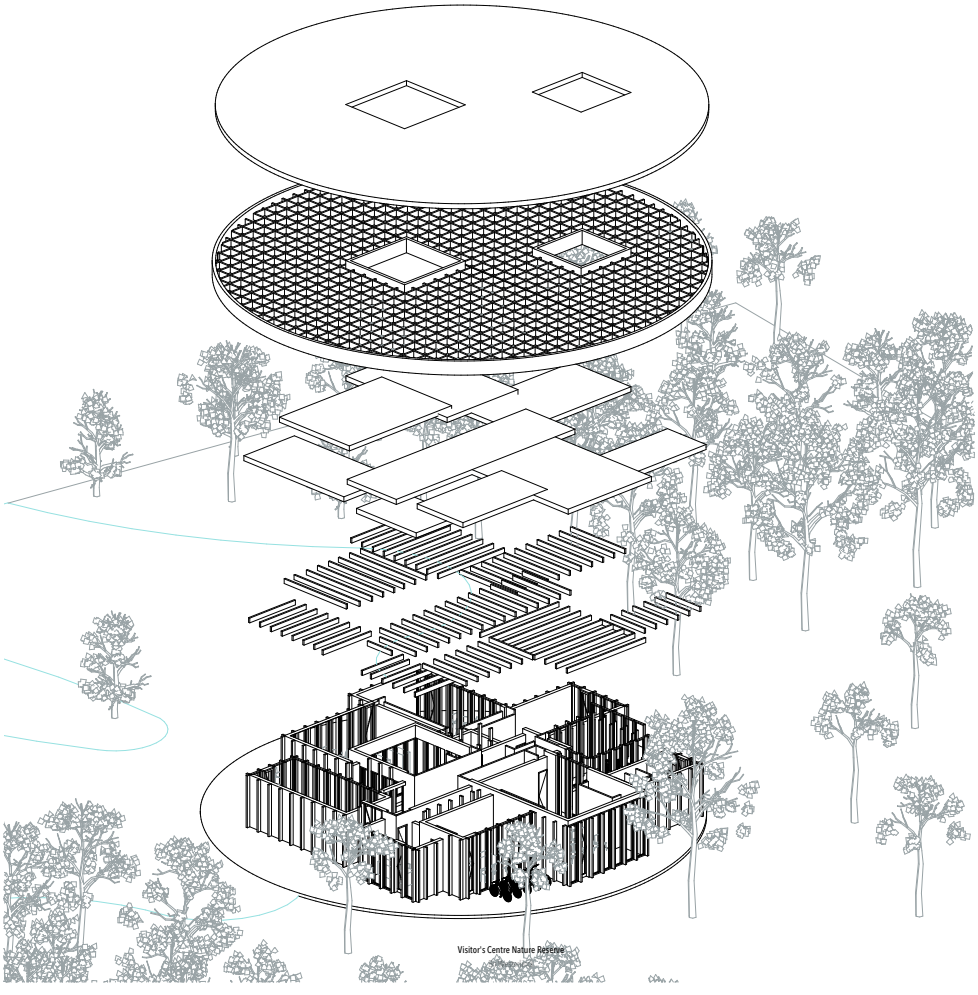
Floor plan visitors centre panel, own production, Bo Westerlinck



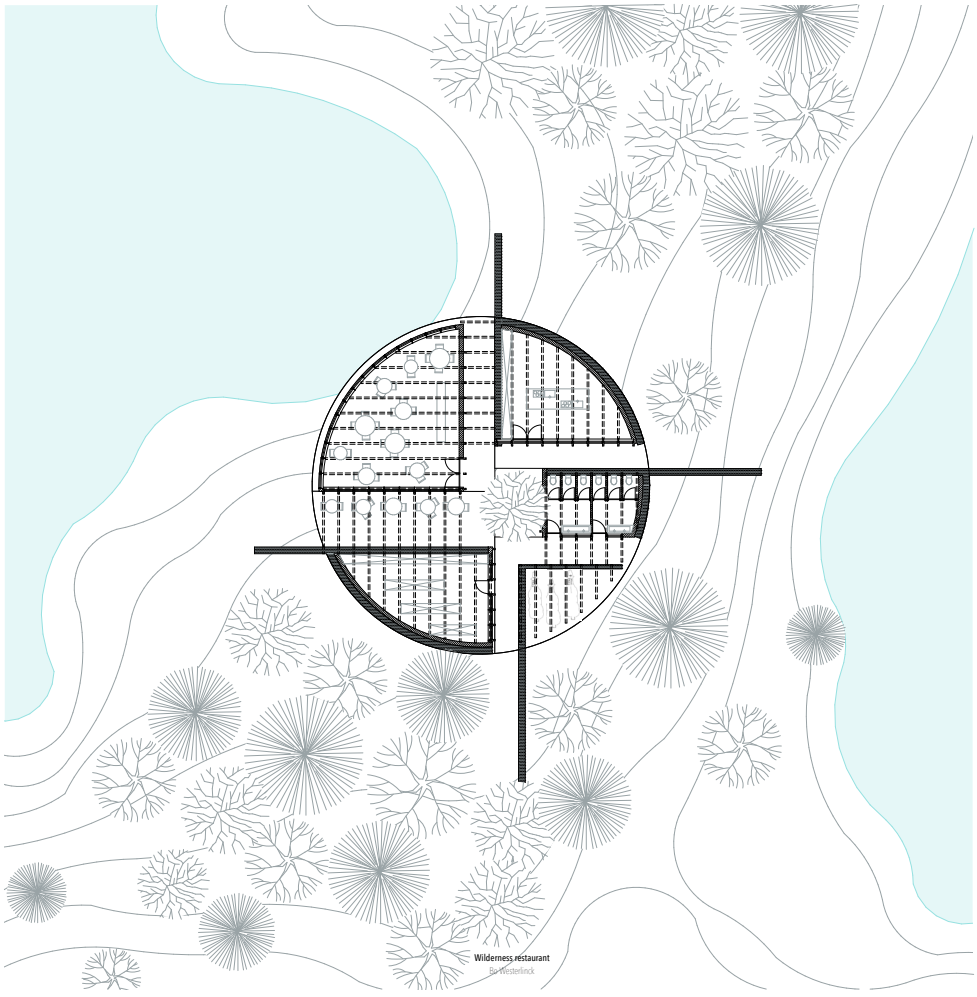
Roof plan visitors centre panel, own production, Bo Westerlinck



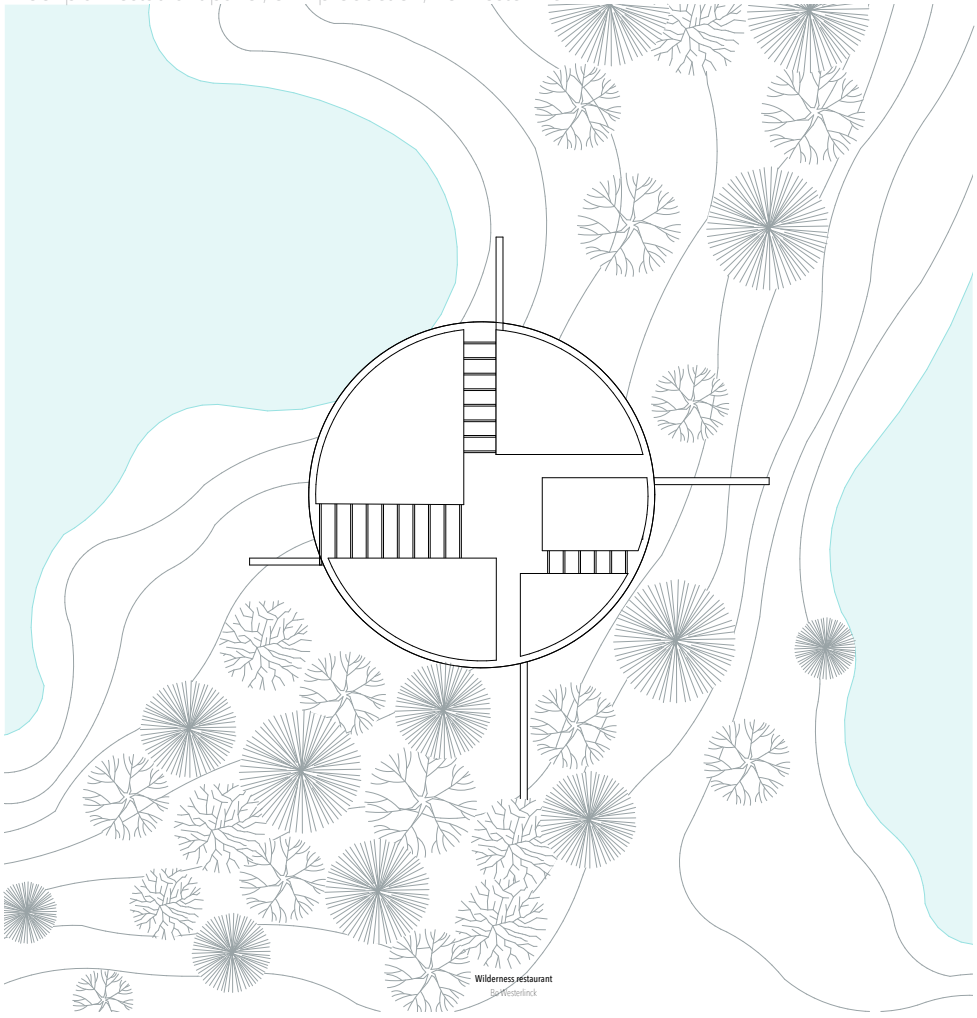
Sections and elevations visitors centre panel, own production, Bo Westerlinck



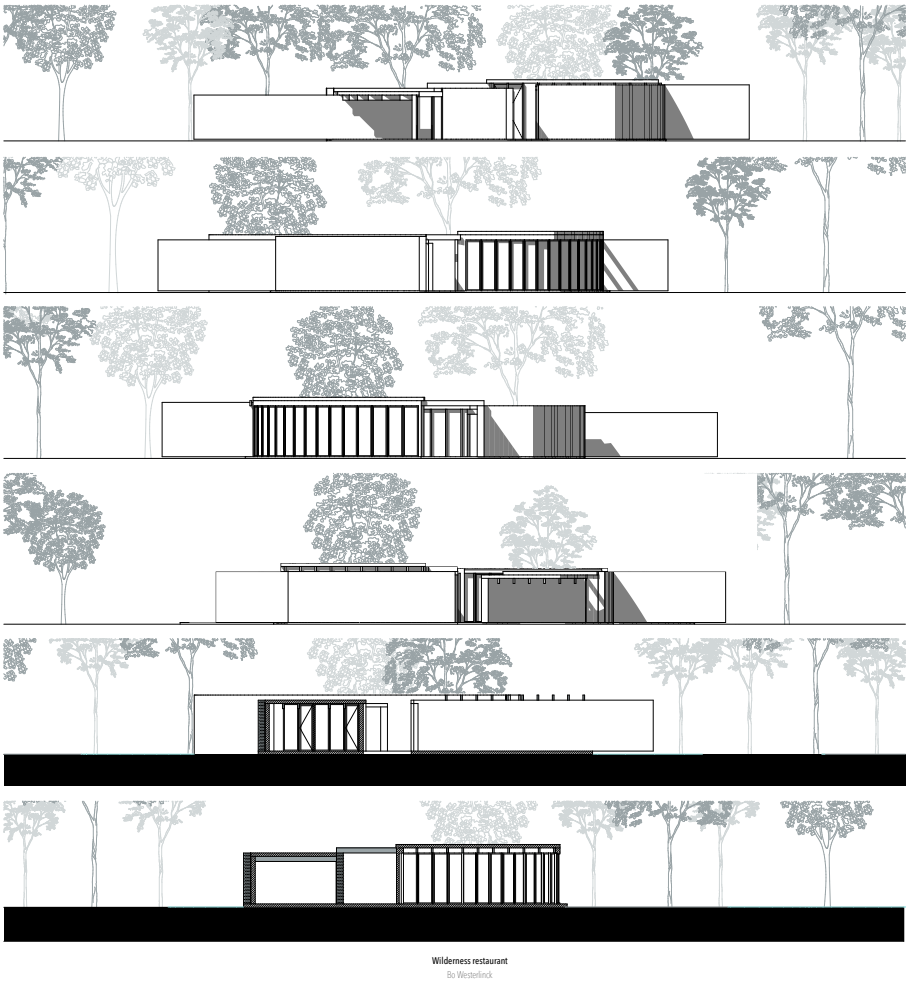
Exploded axonometric view visitors centre panel, own production, Bo Westerlinck



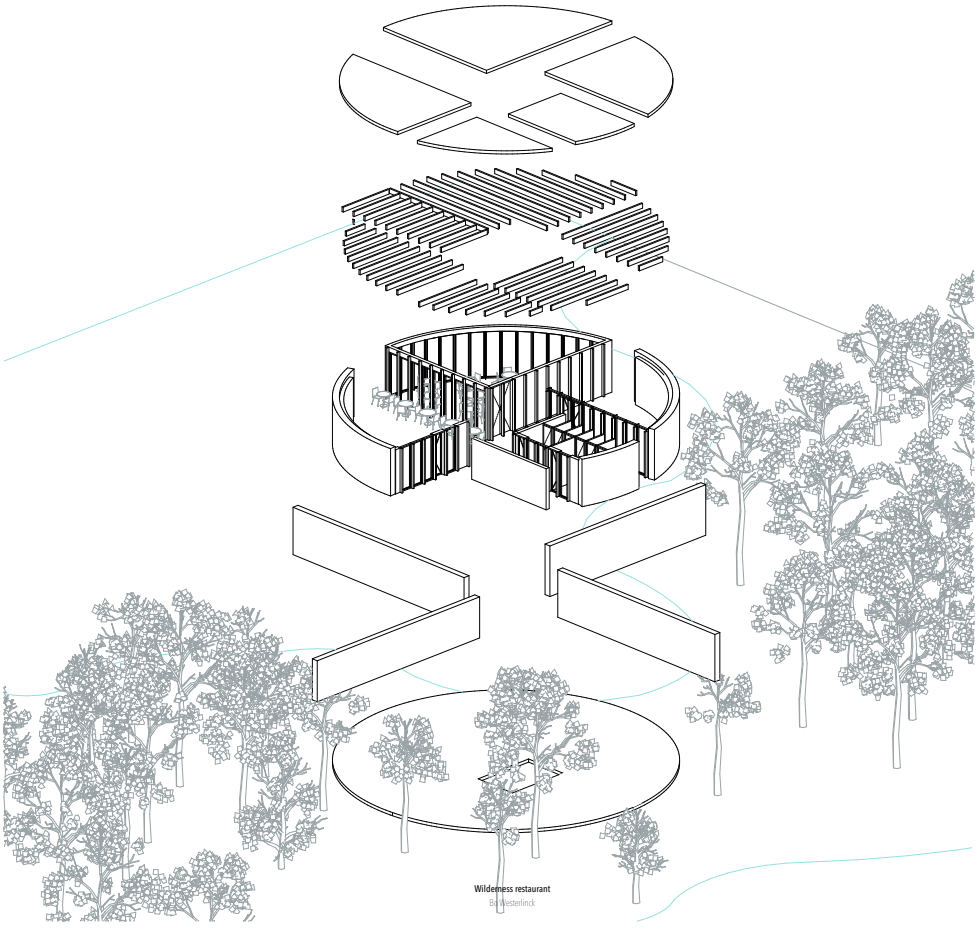
Floor plan restaurant panel, own production, Bo Westerlinck



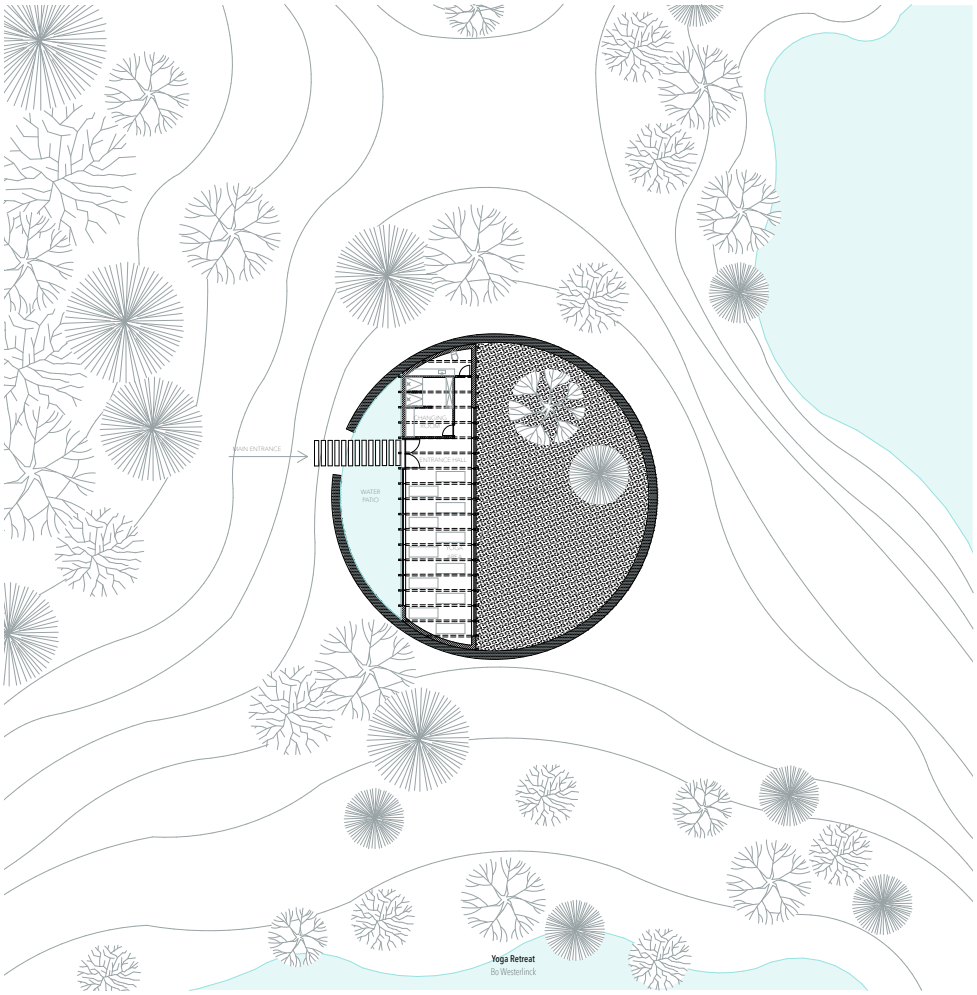
Roof plan restaurant panel, own production, Bo Westerlinck



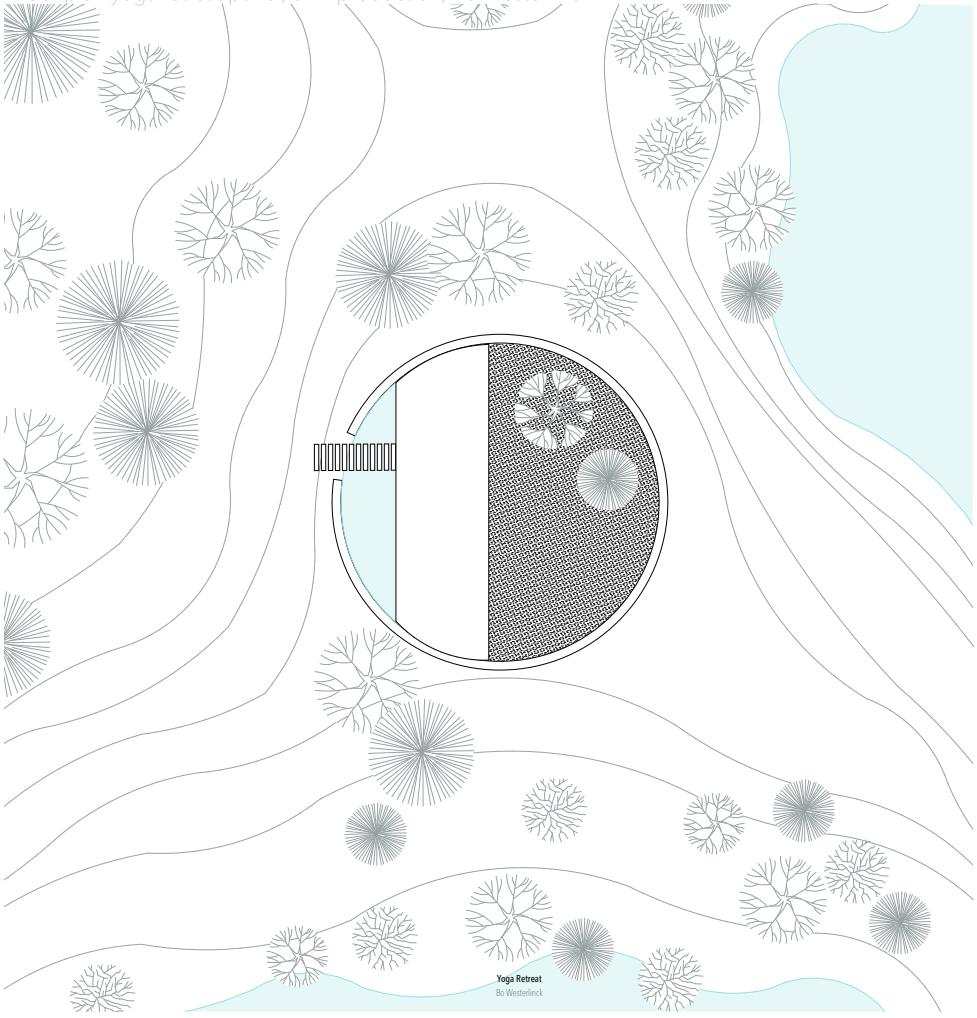
Sections and elevations restaurant panel, own production, Bo Westerlinck



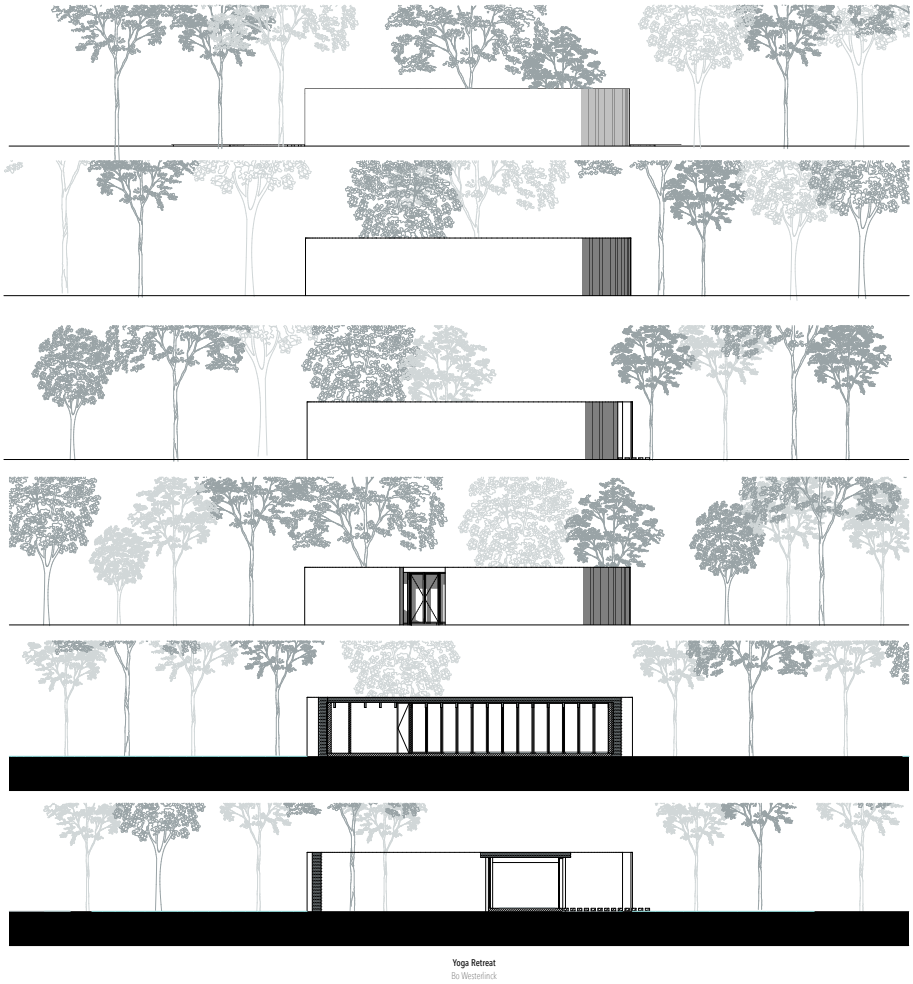
Exploded axonometric view restaurant panel, own production, Bo Westerlinck



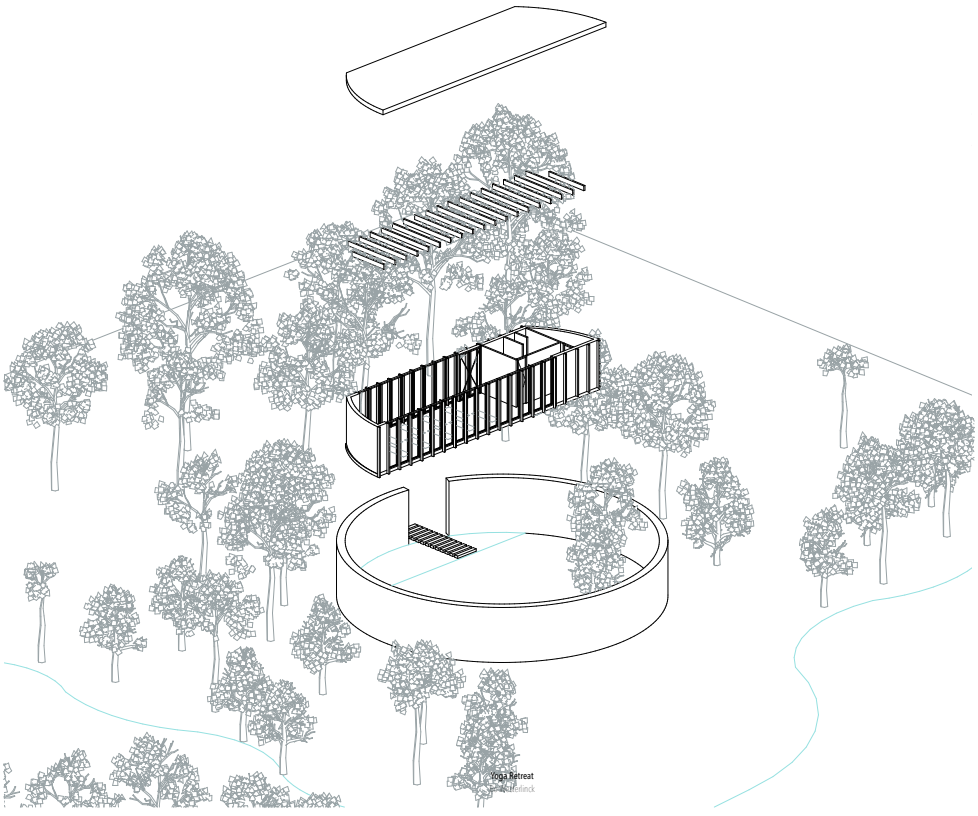
Floor plan yoga retreat panel, own production, Bo Westerlinck



Roof plan yoga retreat panel, own production, Bo Westerlinck



Sections and elevations yoga retreat panel, own production, Bo Westerlinck



Exploded axonometric view yoga retreat panel, own production, Bo Westerlinck

Render exterior visitors centre, own production, Bo Westerlinck

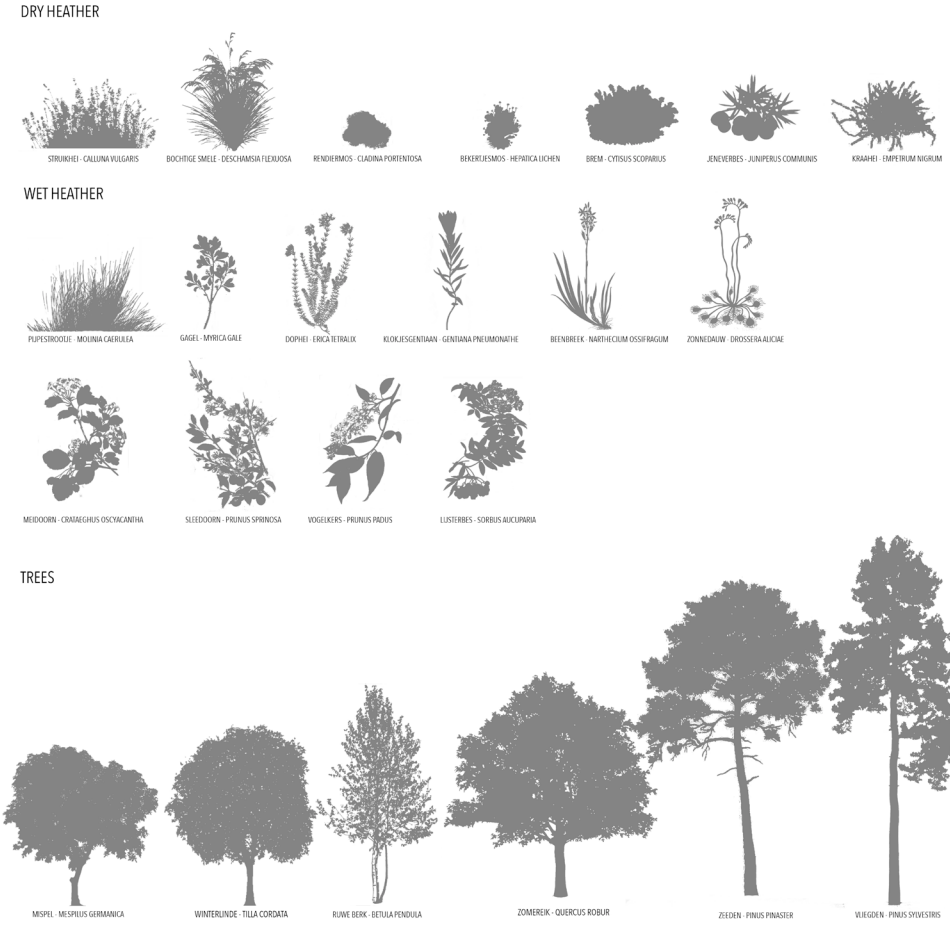
Render auditorium visitors centre, own production, Bo Westerlinck

Render exterior restaurant, own production, Bo Westerlinck

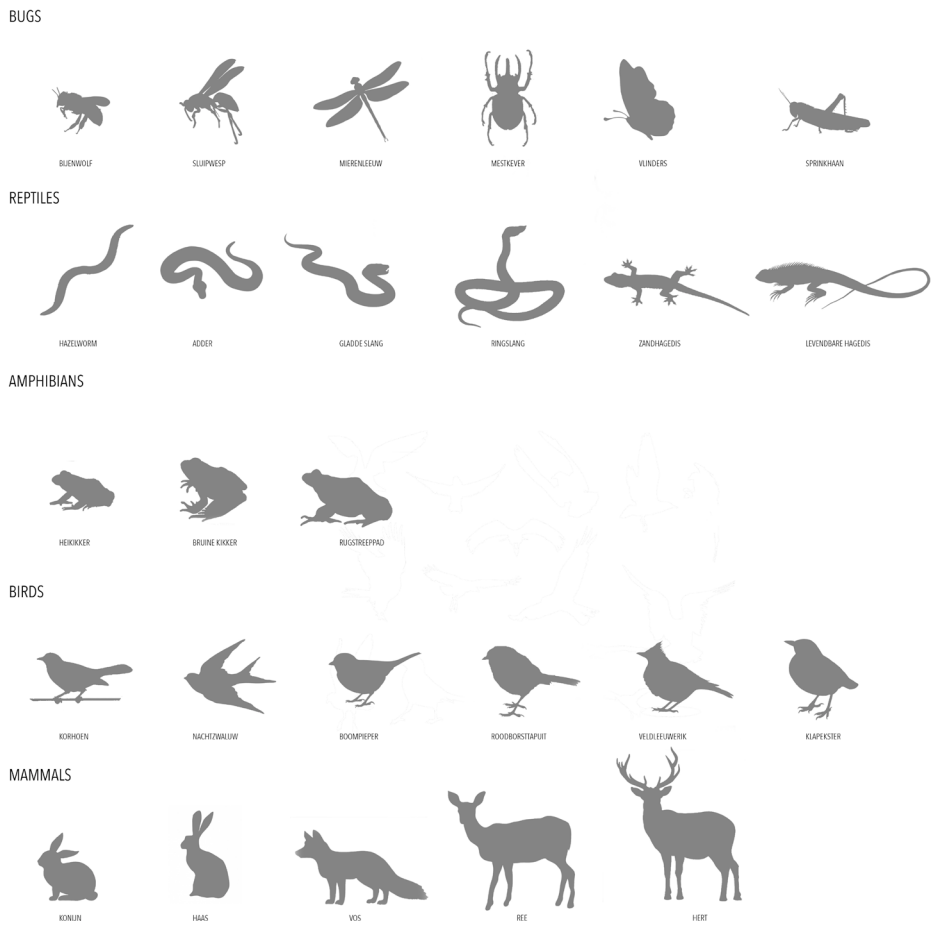
Render entrance restaurant, own production, Bo Westerlinck

Render exterior yoga retreat, own production, Bo Westerlinck

Render interior patio yoga retreat, own production, Bo Westerlinck



Biodiversity research plant species, own production, Bo Westerlinck



Biodiversity research animal species, own production, Bo Westerlinck

Different kinds of nature as a guiding principle
Bo Westerlinck

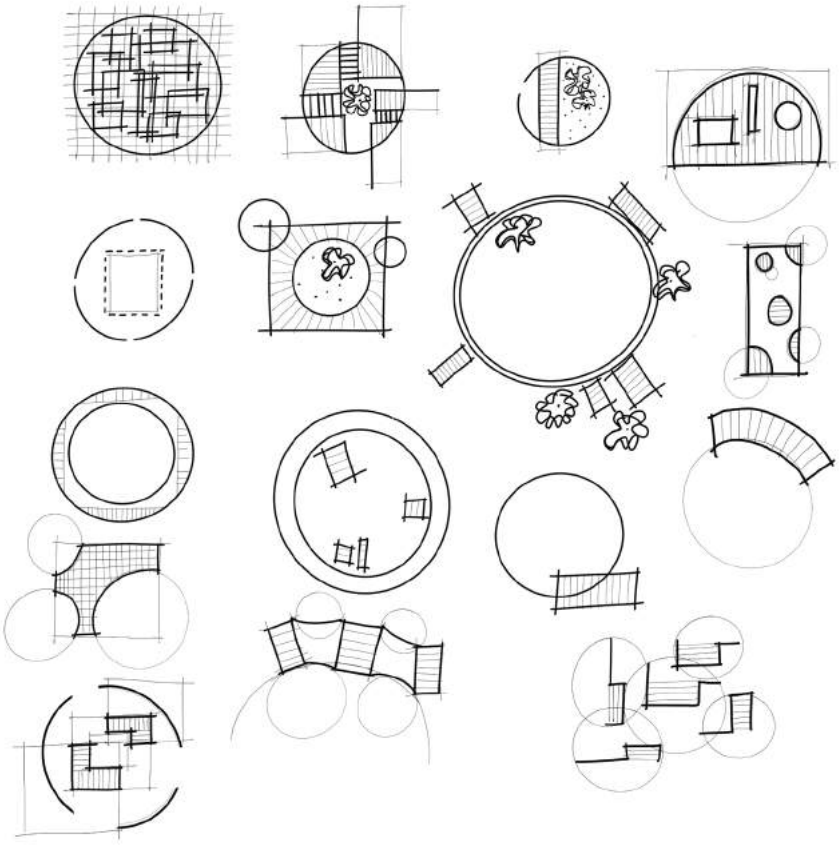
Different kinds of nature as a guiding principle, own production, Bo Westerlinck

Atmosphere pavilions
Bo Westerlinck

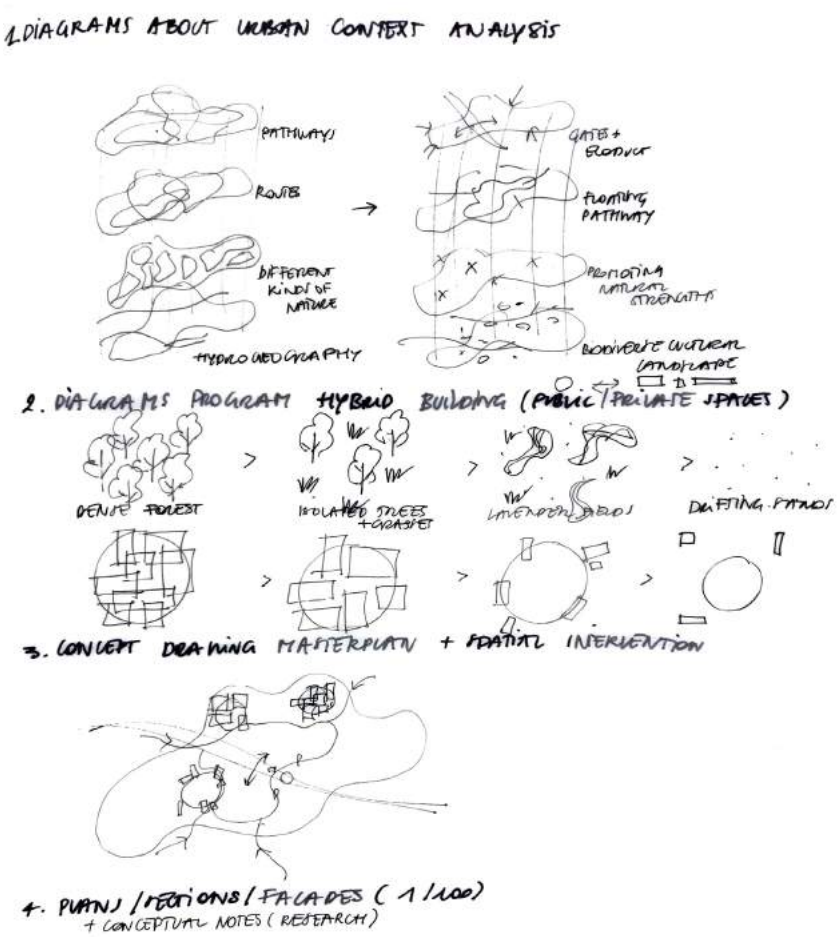
Atmosphere pavilions, own production, Bo Westerlinck

Moodboard natural materials, own production, Bo Westerlinck

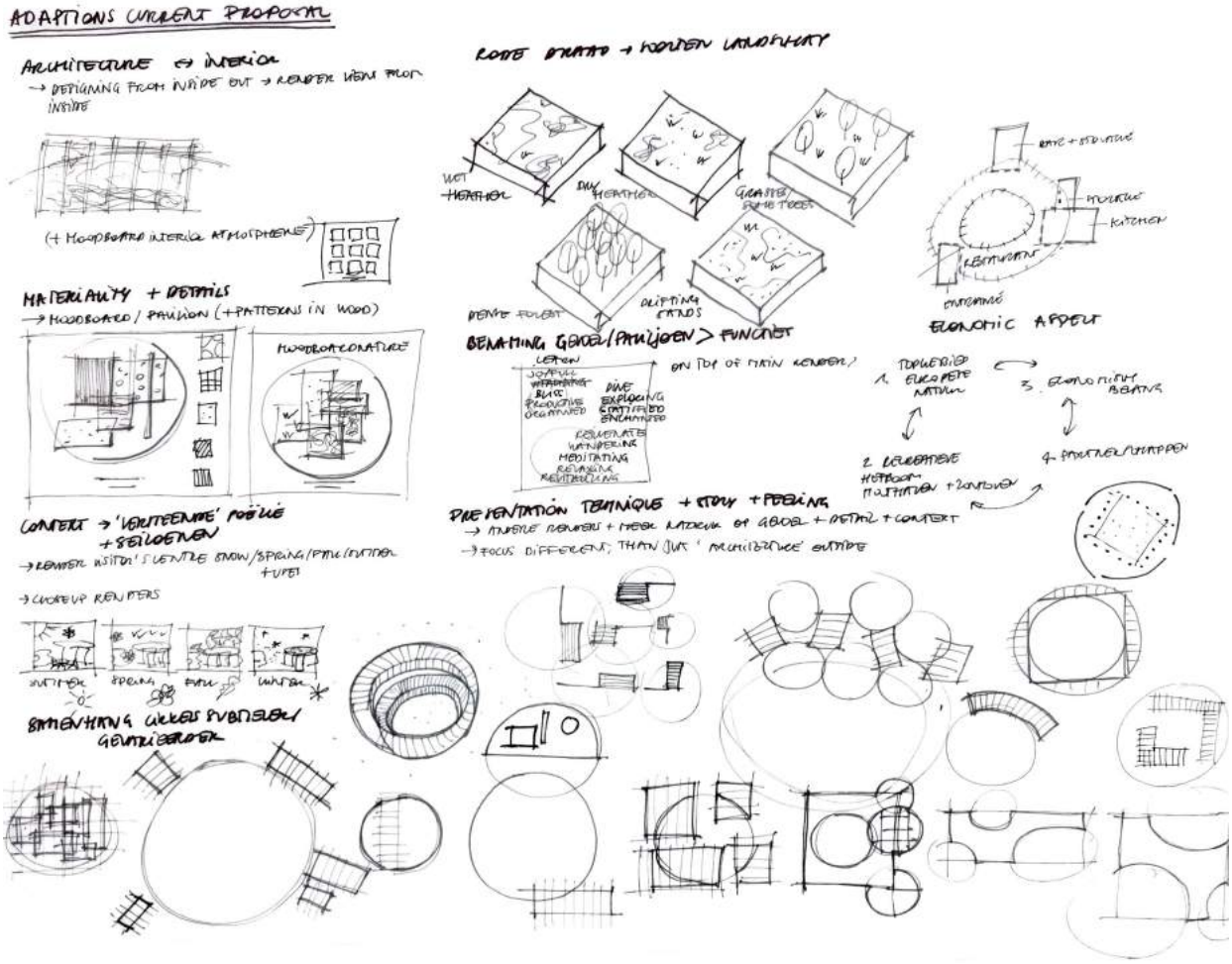
Moodboard materials design, own production, Bo Westerlinck



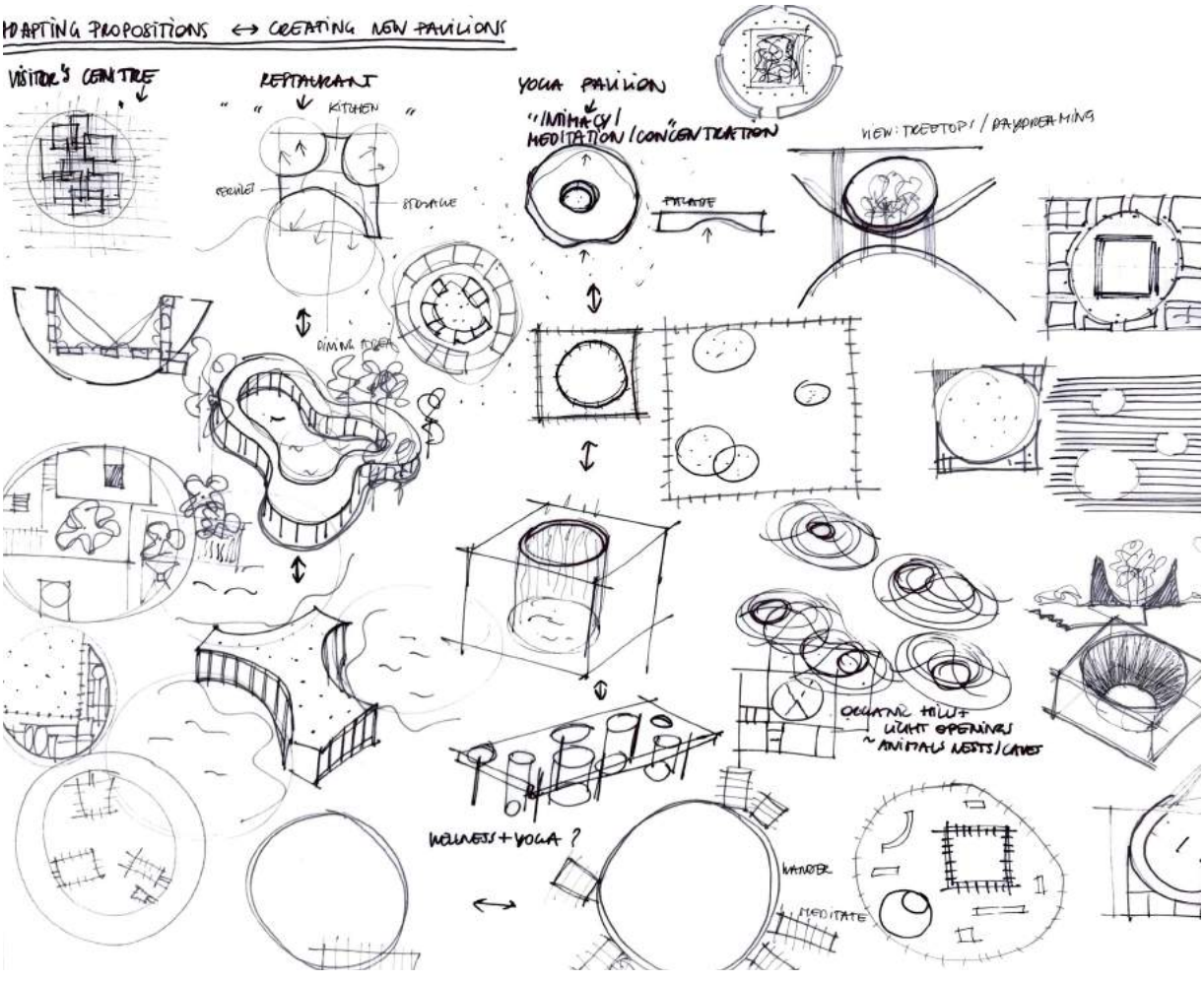
Principle sketches of working with patterns, own production, Bo Westerlinck



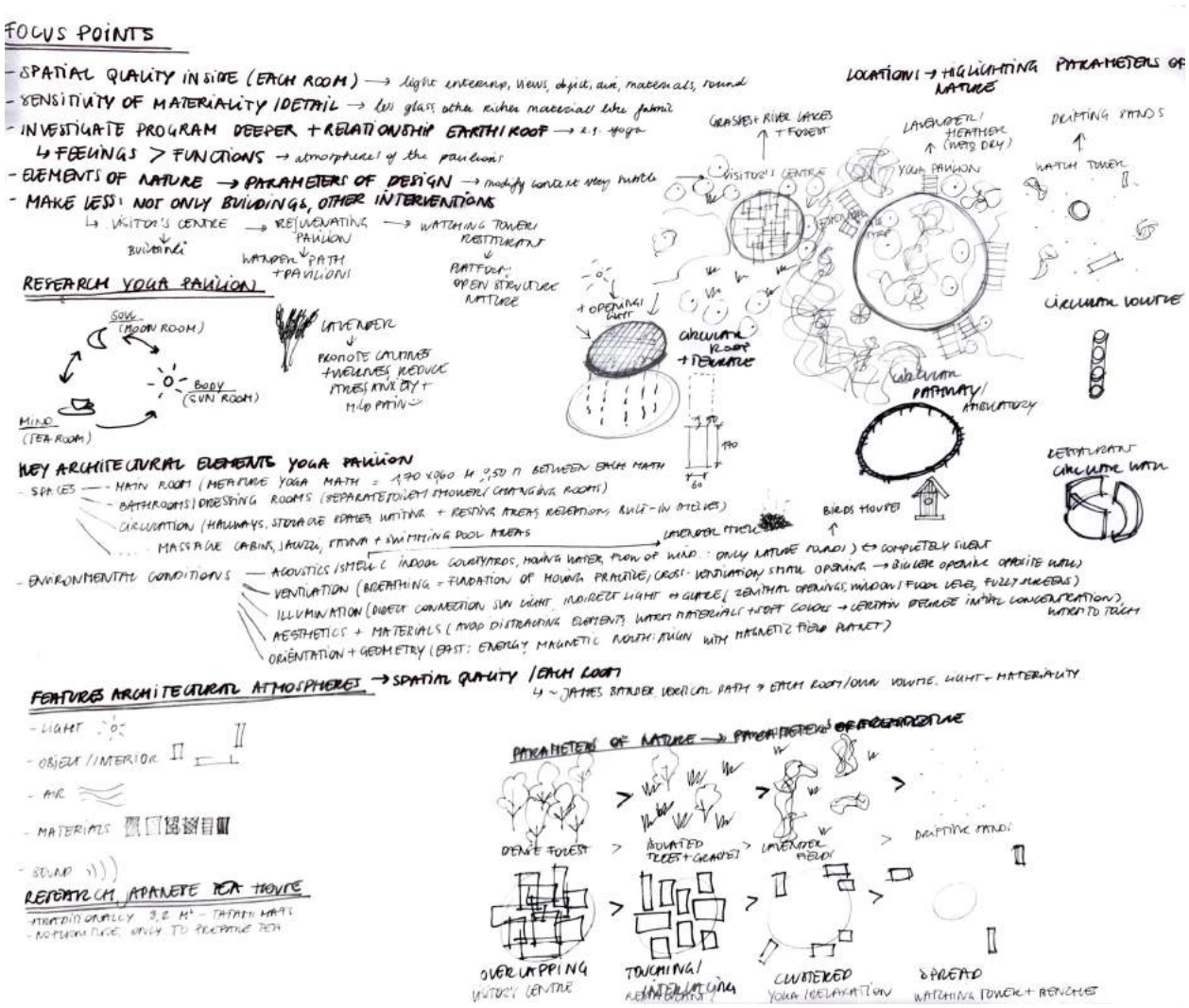
Overall pattern language strategy, own production, Bo Westerlinck



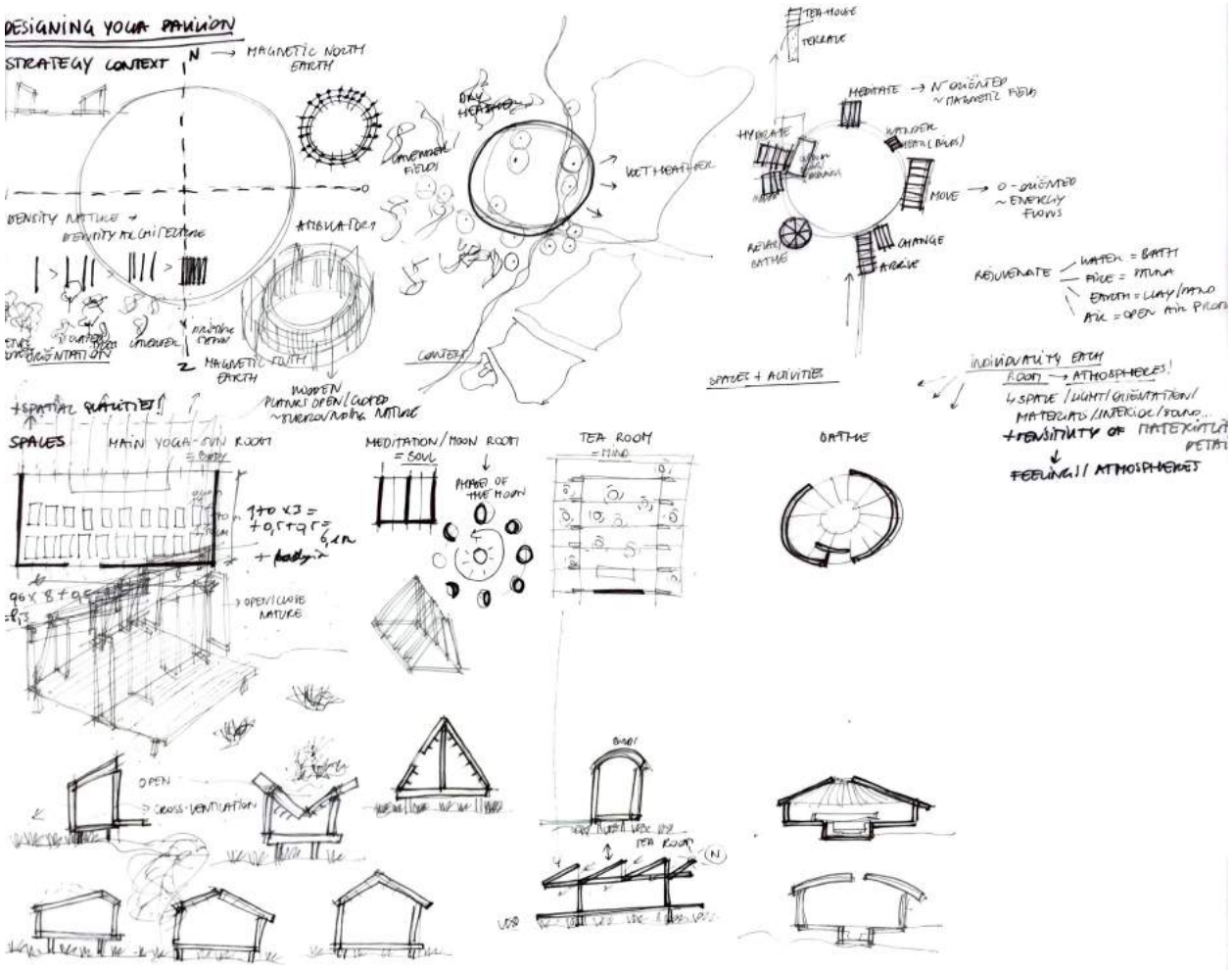
Design sketches adaptations current proposal, own production, Bo Westerlinck



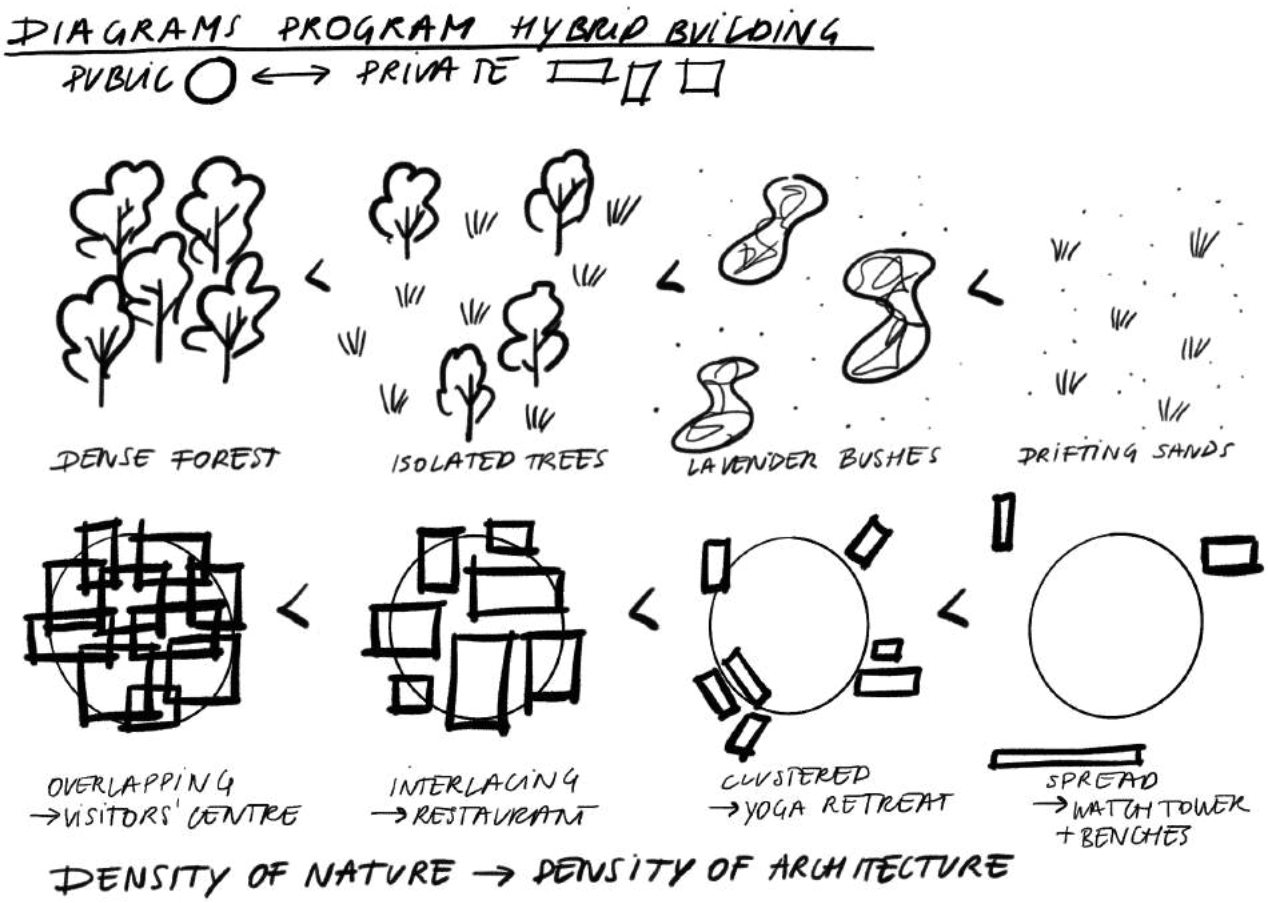
Design sketches adapting proportions, own production, Bo Westerlinck



Design sketches focus points and overall strategy, own production, Bo Westerlinck



Design sketches new pavilion, own production, Bo Westerlinck



Diagrams density of nature to density of architecture, own production, Bo Westerlinck

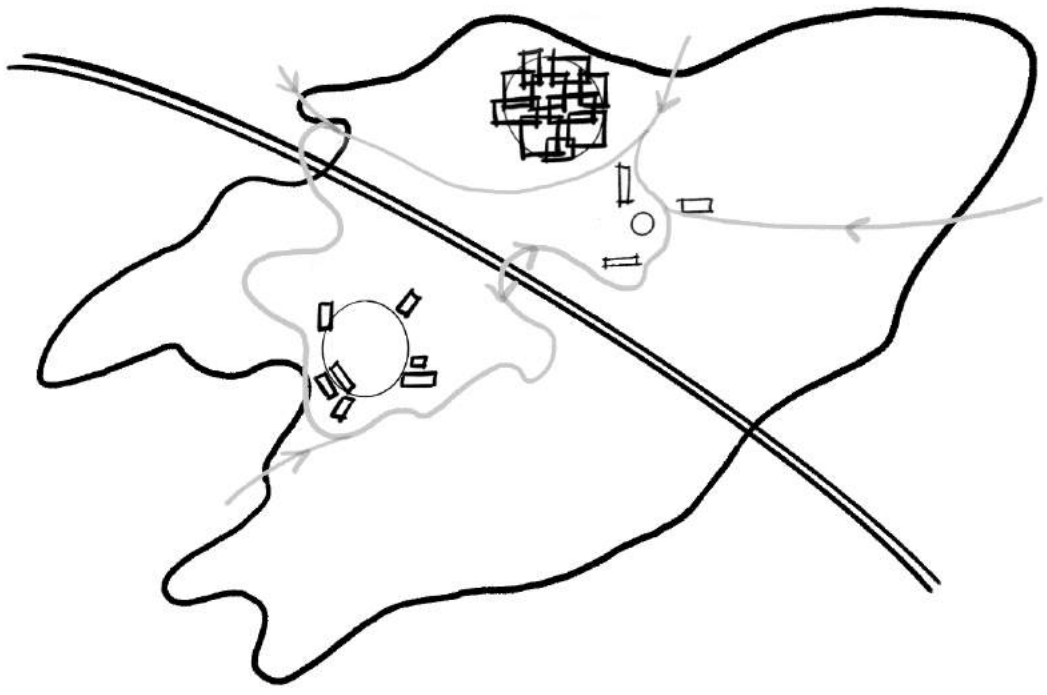
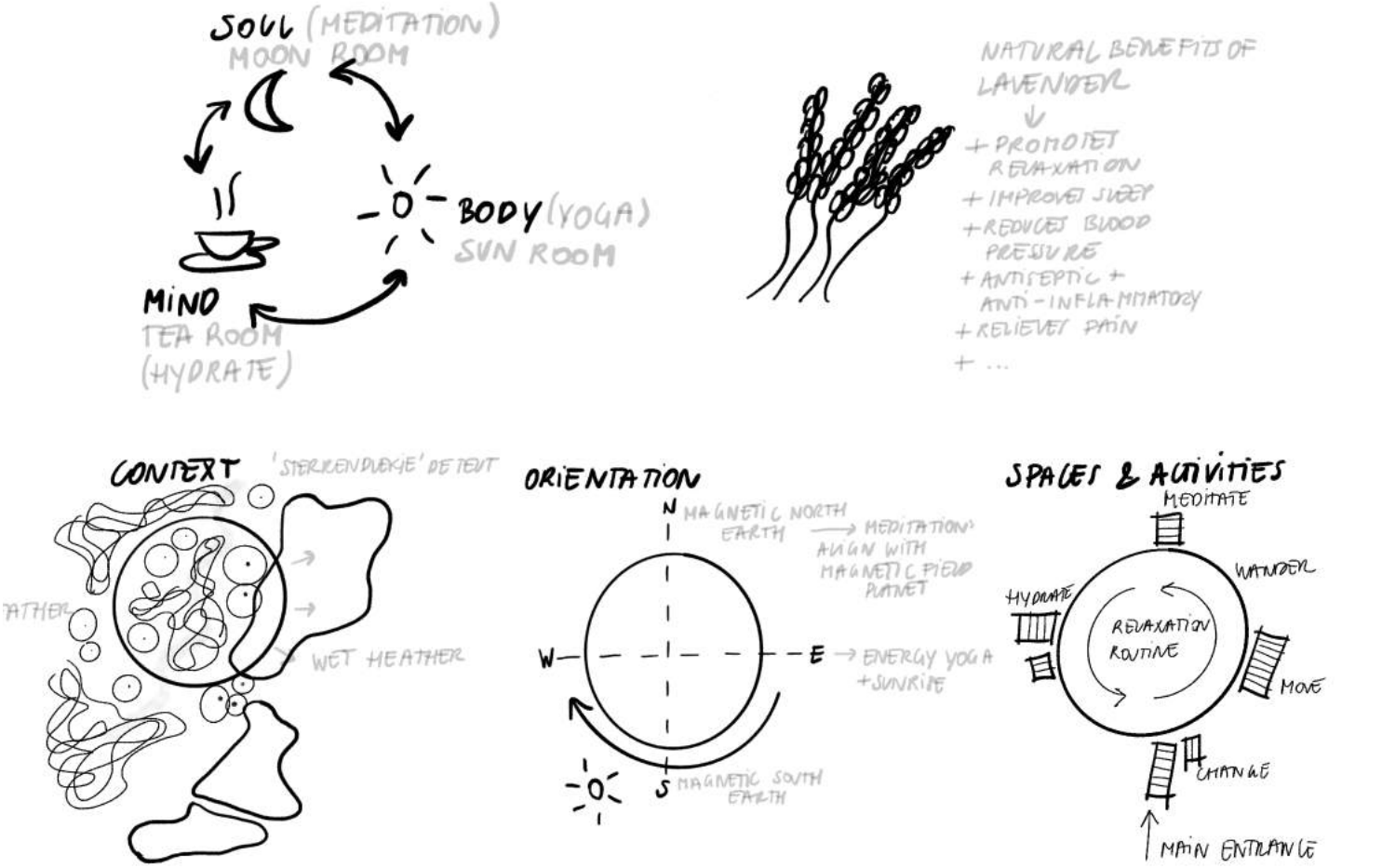
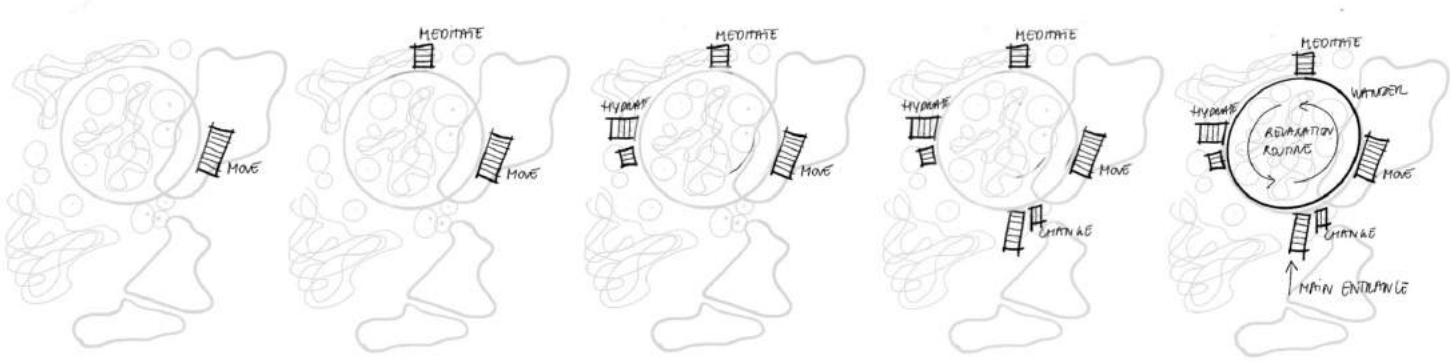


Diagram integration different pavilions in master plan, own production, Bo Westerlinck

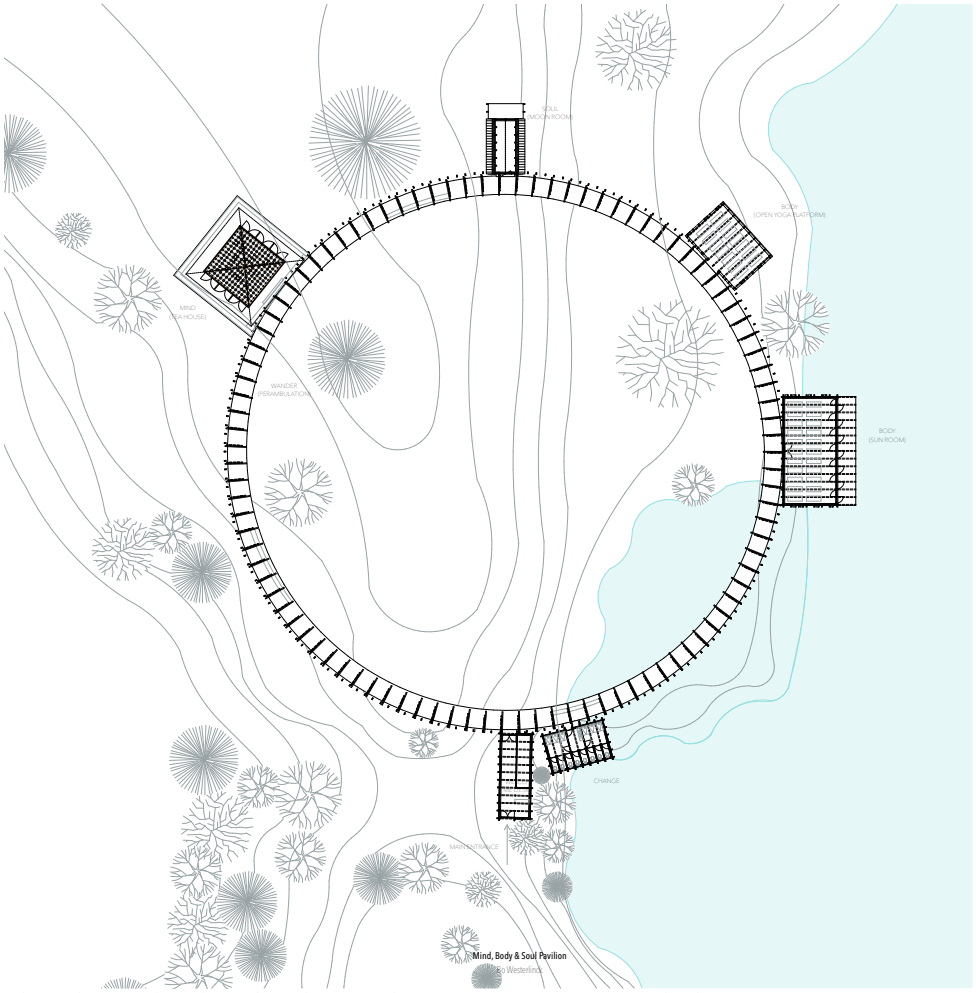


Design sketches mind-body-soul pavilion, own production, Bo Westerlinck

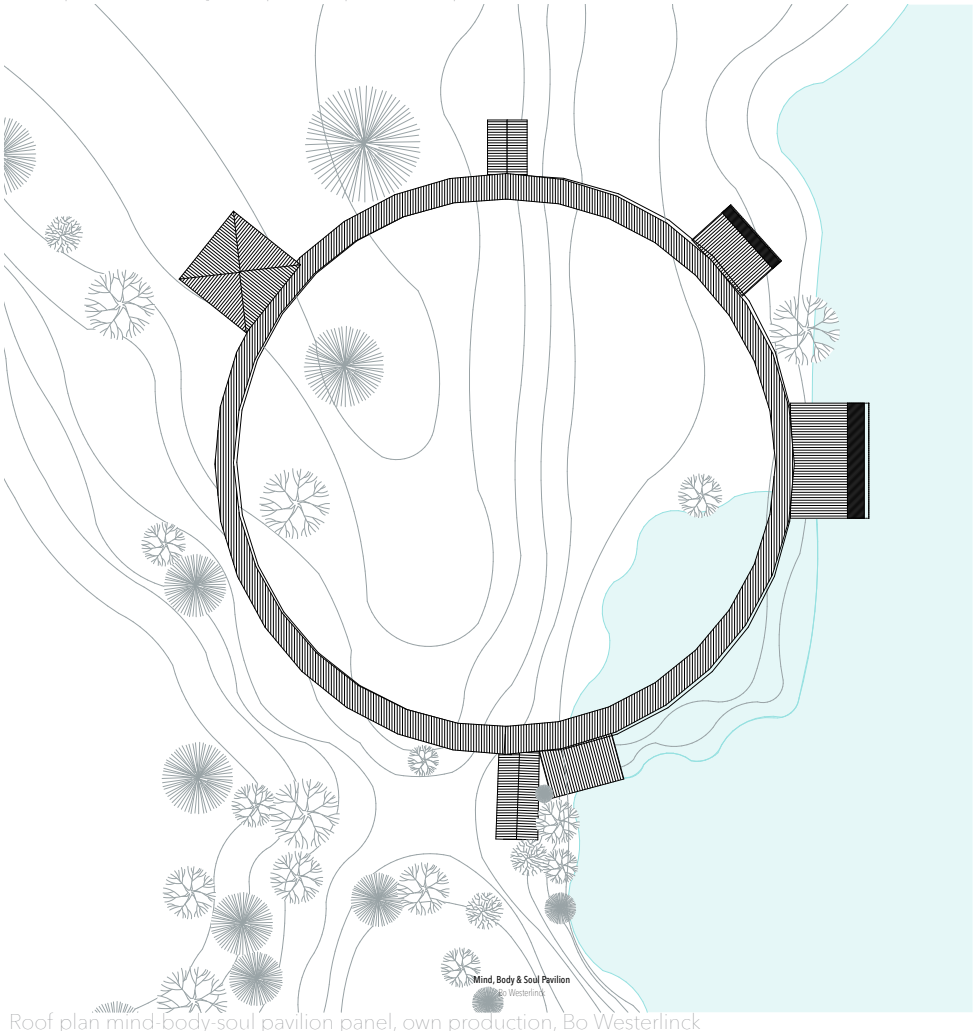
POSSIBLE EVOLUTION SCHEME



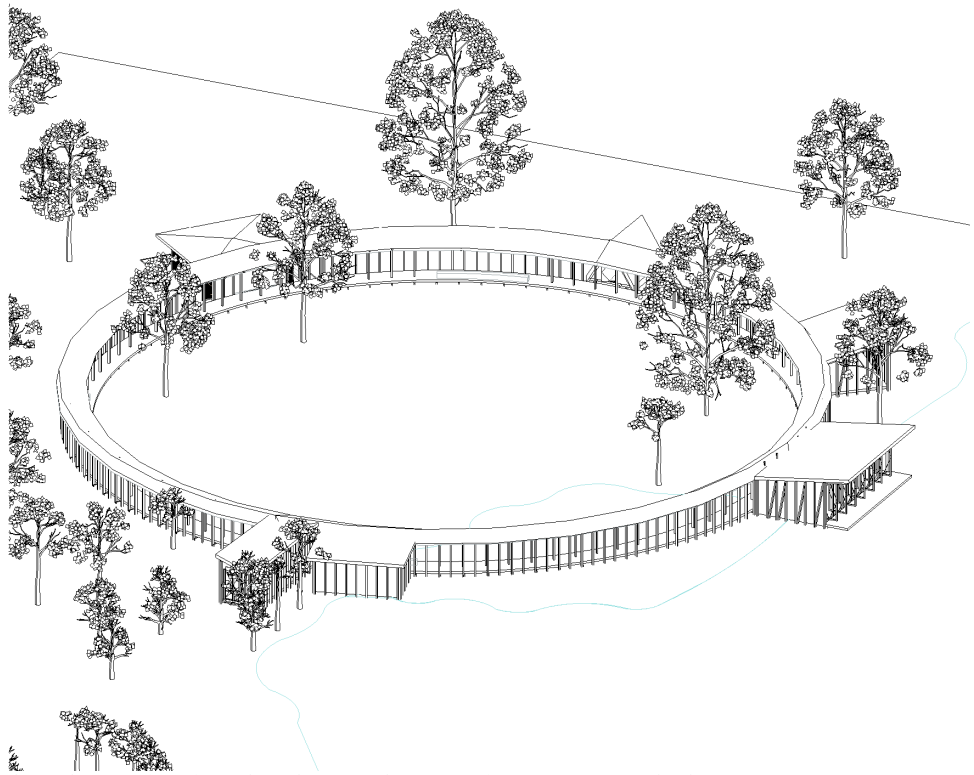
Possible evolution scheme of mind-body-soul pavilion, own production, Bo Westerlinck



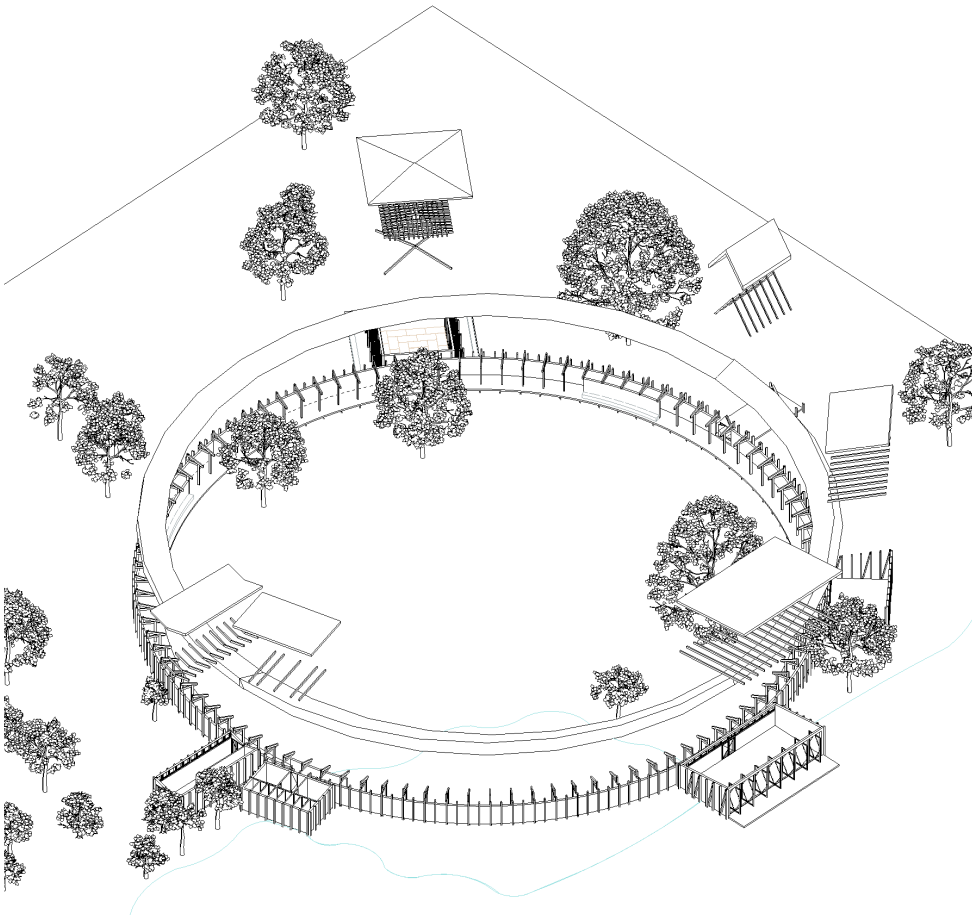
Floor plan mind-body-soul pavilion panel, own production, Bo Westerlinck



Roof plan mind-body-soul pavilion panel, own production, Bo Westerlinck



Floor plan mind-body-soul pavilion panel, own production, Bo Westerlinck



Roof plan mind-body-soul pavilion panel, own production, Bo Westerlinck

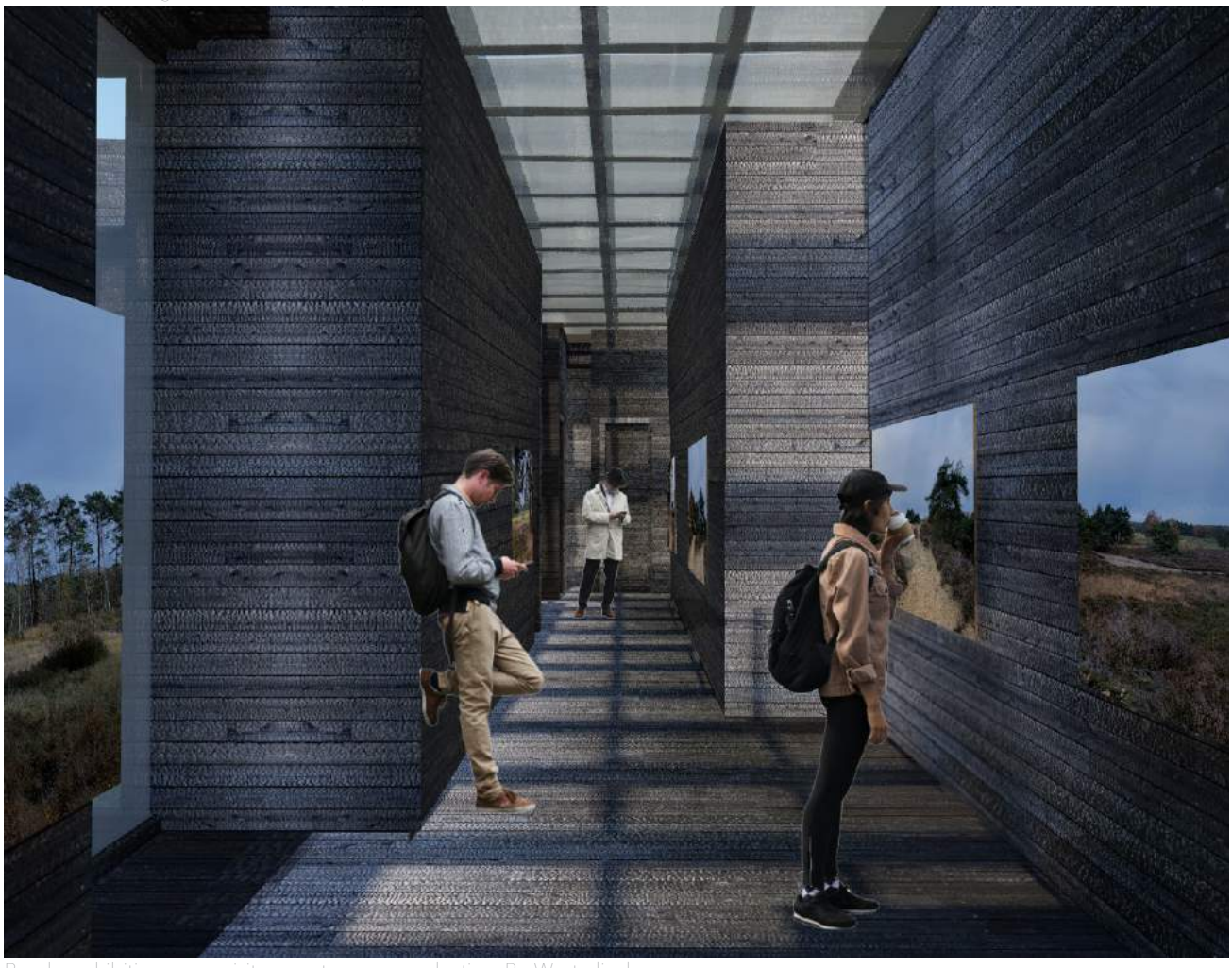
Render exterior mind-body-soul pavilion, own production, Bo Westerlinck

Render ambulatory mind-body-soul pavilion, own production, Bo Westerlinck

Render exterior visitors centre (charred wood), own production, Bo Westerlinck

Render exterior visitors centre (light wood), own production, Bo Westerlinck

Render bike storage visitors centre, own production, Bo Westerlinck



Render exhibition space visitors centre, own production, Bo Westerlinck

OWN MASTER PROJECT

2. IDENTIFICATION CHALLENGES

2.4. CONCLUSION IDENTIFICATION

From previous experiments about how we can deal with this natural landscape as a designer or architect, we can conclude that it is always very important to first carry out a thorough analysis of the entire nature reserve. This on meso, macro as well as micro scale. Next, we try to recognize certain structures and opportunities, with which we can develop the overall project strategy, subdivided into different focal points or aims. Subsequently, very strategic places are chosen where various smaller interventions can be developed, this always in close dialogue with the local context. Moreover, these interventions can remain linked to a global coherence or a similar approach or pattern that was used during their design of each of them.

In this way we strive to obtain a very global design vision for the whole area, with very contextual and sensitive pavilions or interventions in a few strategic places. This combination ensures that people and nature (both plants and animals) can live in synergy with each other.

By doing this, the last proposal is much more fine-tuned on the needs and strengths of the entire nature reserve and on each of the specific locations of the interventions, in stead of combining all the functions into one big community gate which is just situated at the edge of it. By creating these pavilions and connecting them with a wooden floating pathway, the visitors can experience the entire nature reserve in stead of just stopping by at the edge of it.

OWN MASTER PROJECT

3. CLASSIFICATION MASTER PROJECT

3.1. MAIN CONCEPT & AMBITIONS

Thus the main research question that was kept in mind during this design process is: 'How to transform patterns found in nature to patterns of architecture'. It was my ambition to connect people back to nature and at the same time back to each other, specifically through these design patterns.

3.2. MASTER PLAN

After exploring different ways of how to approach this nature reserve and overall design strategy was developed, in which a floating pathway connects three strategic interventions. Namely a visitors centre at the north gate of the nature reserve in which people can learn about this reserve or carry out functions that are otherwise not possible in nature, subsequently a watchtower that provides a beautiful view over the entire reserve, lastly a mind-body-soul pavilion in which people can really relax inside this beautiful nature. In the resting area of the animals an ecoduct is added to let the nature reserve function as one reserve again, like before the division by the highway E314.

3.3. FLOOR PLANS

For the floor plans I really tried to go back to the roots of architecture and use very primary shapes as a pursuit to simplicity .The organisation of these circular and orthogonal shaped floor plans corresponds to different densities of nature. The visitors centre is situated in a more dense forest, therefore the orthogonal shapes overlap under a circular canopy, furthermore the watchtower is situated on a drifting sands hill, therefore the tower and some sitting benches are spread out very open. Last, the mind-body-soul pavilion is situated in the lavender, an enclosed circular pathway connects touching orthogonal volumes connected to this.

3.4. SECTIONS

I really focused on how to experiment this nature reserve in different ways, and which different feelings I wanted to evoke when inside these pavilions. This was mainly my inspiration when designing the sections.

3.5. ELEVATIONS

When designing the elevations, obviously I focussed on what natural features you would see when you are inside the architecture. By abstracting the natural environments into patterns, this was very easy to experiment with architecturally. Taking into account the different needs/wishes for each of the integrated functions inside.

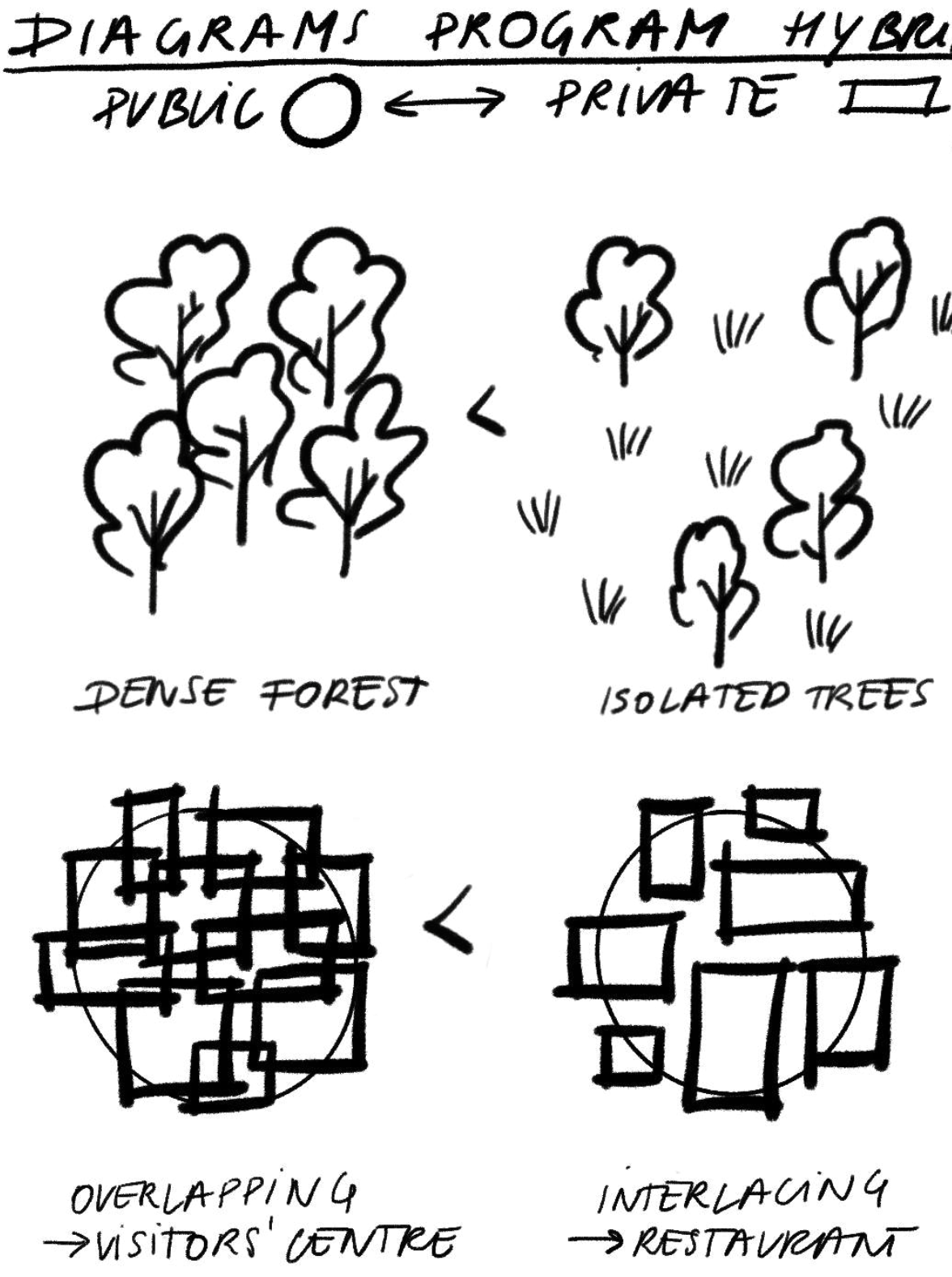
3.6. VISUALISATIONS

The main purpose of the visualisations I made was to see how this architecture could blend best in the surrounding nature. I experimented with different kinds of woods, different sizes and shapes of wooden planks etc.,... The proportions and organisation of the building was determined by the overall guiding patterns that I used, but of course there are still endless details and possibilities that could be explored aesthetically and construction wise.

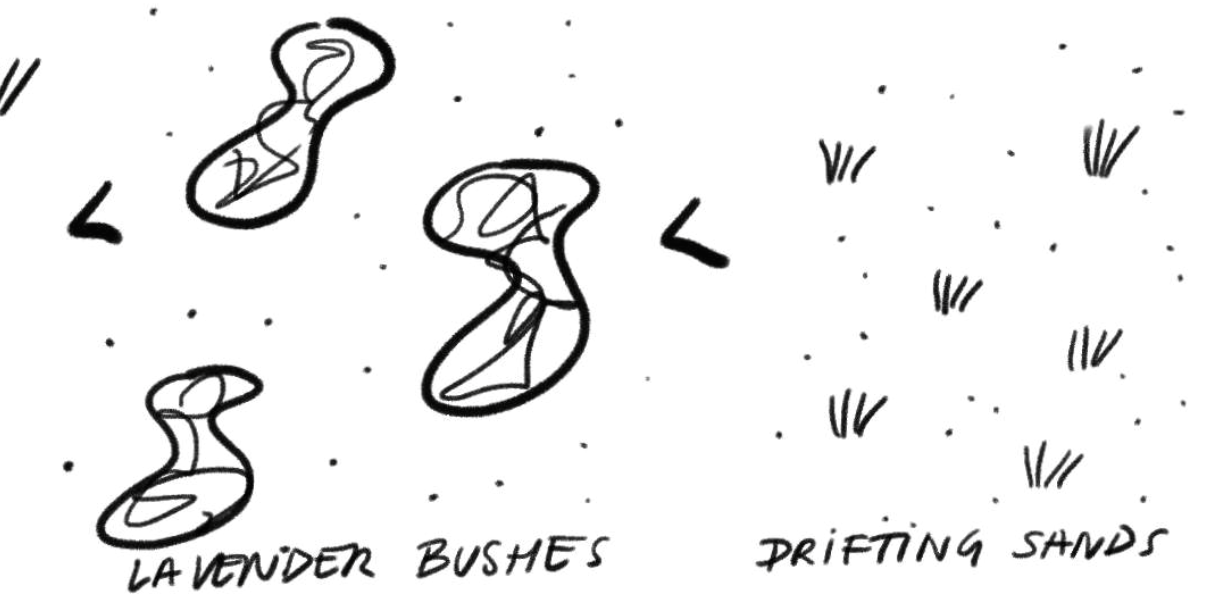
3.7. CONCLUSION DESIGN PROCESS

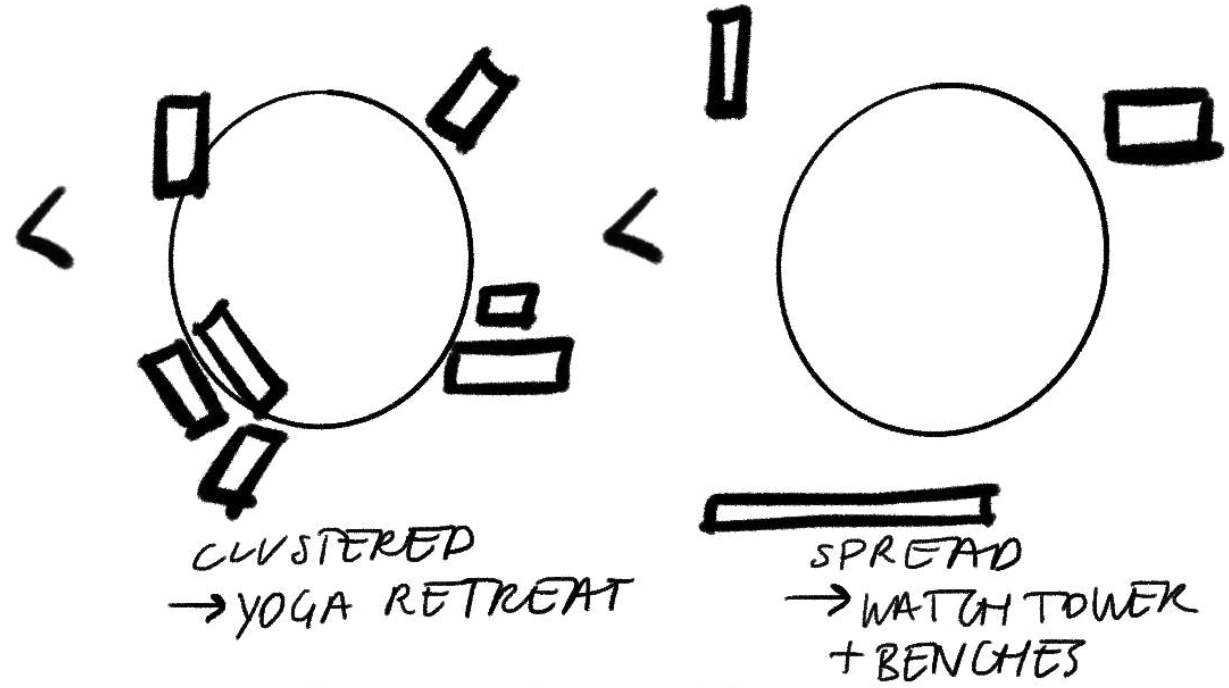
What we can conclude from the previous design process, in which I experimented with different ways of using design patterns, parametricism or new forms of human-nature intelligence, is that communication very transparently about why certain design choices were made allows other to continue working/ experimenting on it. This is a new form of design intelligence that I would like to achieve in order to hopefully inspire other people to use similar techniques as a way to guide their design processes to empirical projects.

Furthermore, it still remains very personal why you make certain choices as a designer, everyone has different values, lives in a different culture etc.,... This is why communicating transparently is so important for this adaptive design method.


DIAGRAMS PROGRAM HYBR
PUBLIC ⟷ PRIVATE
DENSE FOREST
ISOLATED TREES
OVERLAPPING
→VISITORS' CENTRE
INTERLACING
→RESTAURANT
DENSITY OF NATURE → DENS

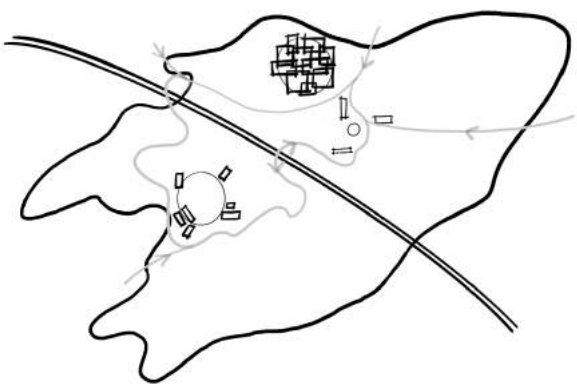
P BUILDING





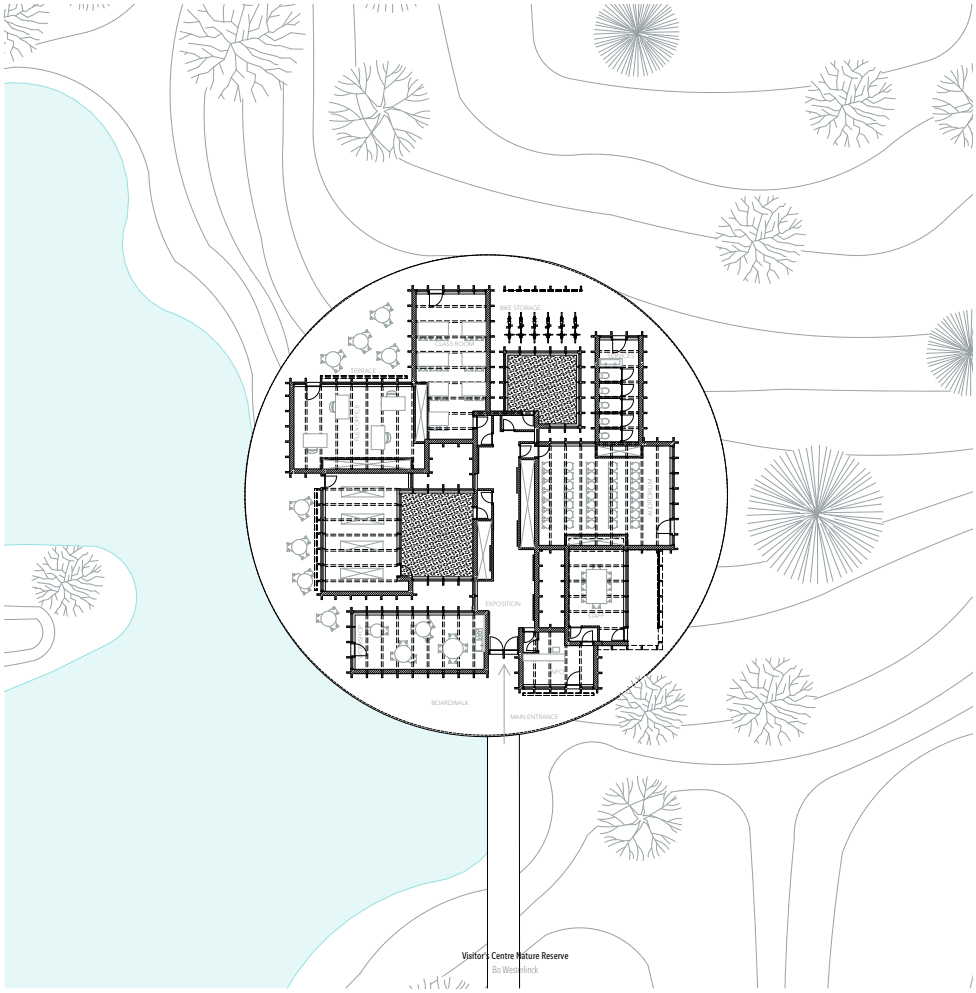
ITY OF ARCHITECTURE


MIND BODY
SOUL
PAVILION

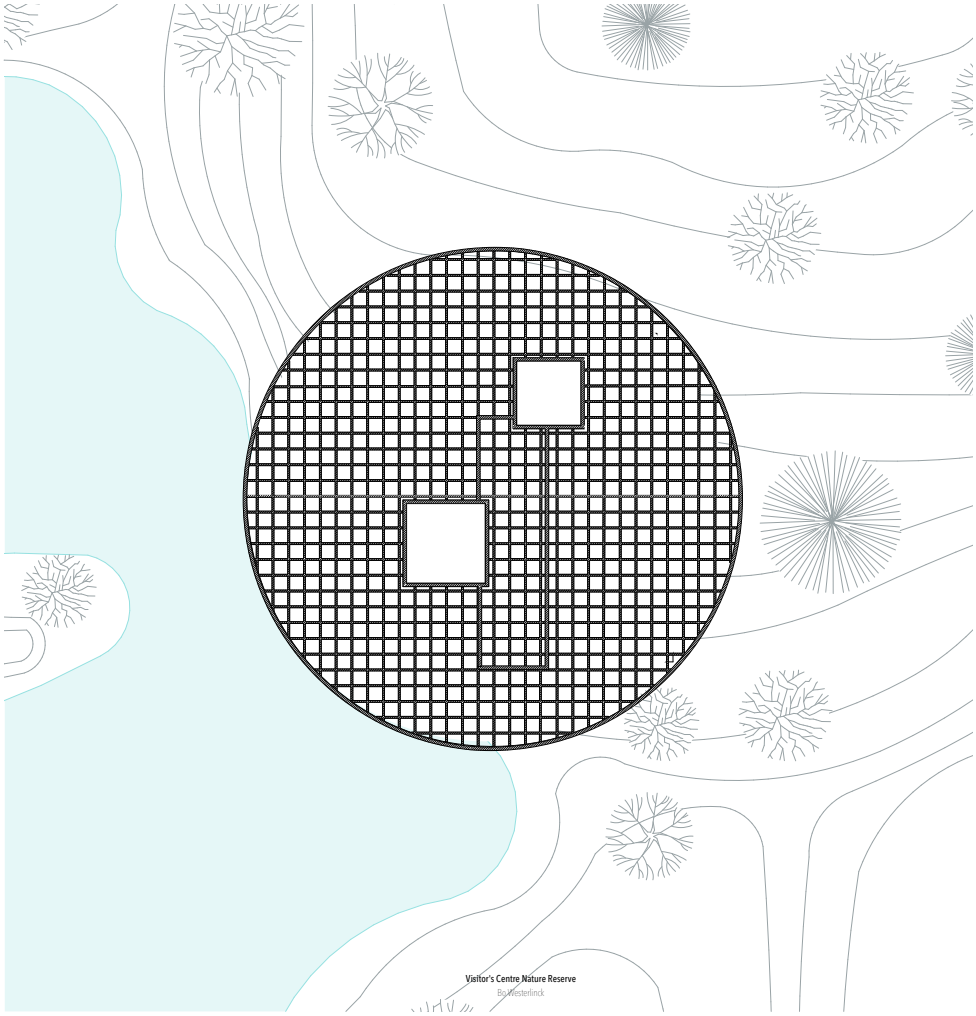



VACATION CENTRE
VISITORS CENTRE
ROYAL GOLF CLUB
VIEWING TOWER
RESTING AREA ANIMALS
ECODUCT ANIMALS

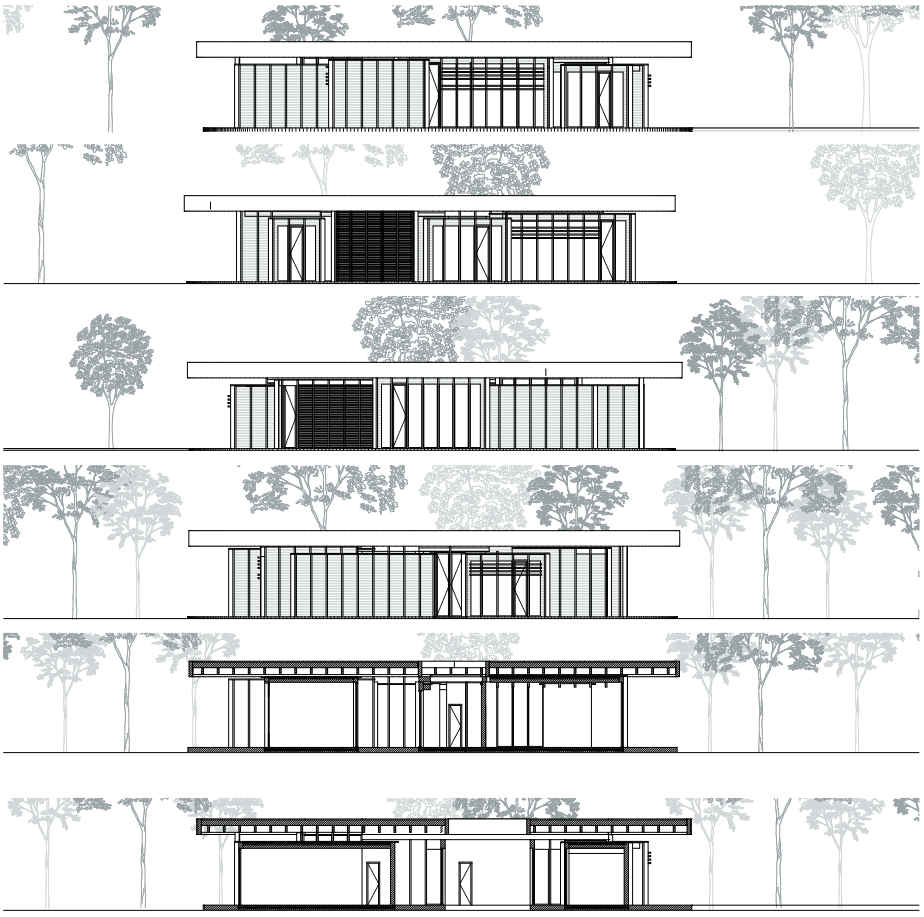

ISOLATED TREES



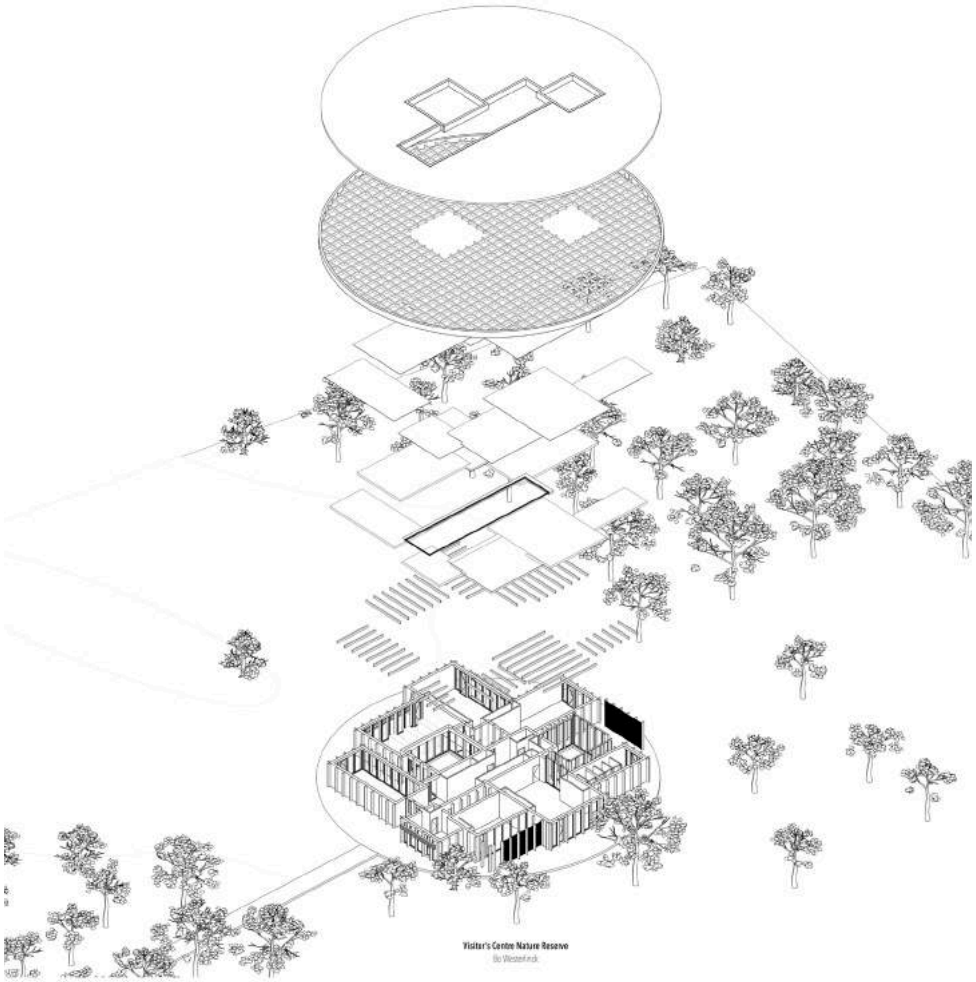
Visitor's Centre Nature Reserve
Bo Westerlinck



Visitor's Centre Nature Reserve
Bo Westerlinck

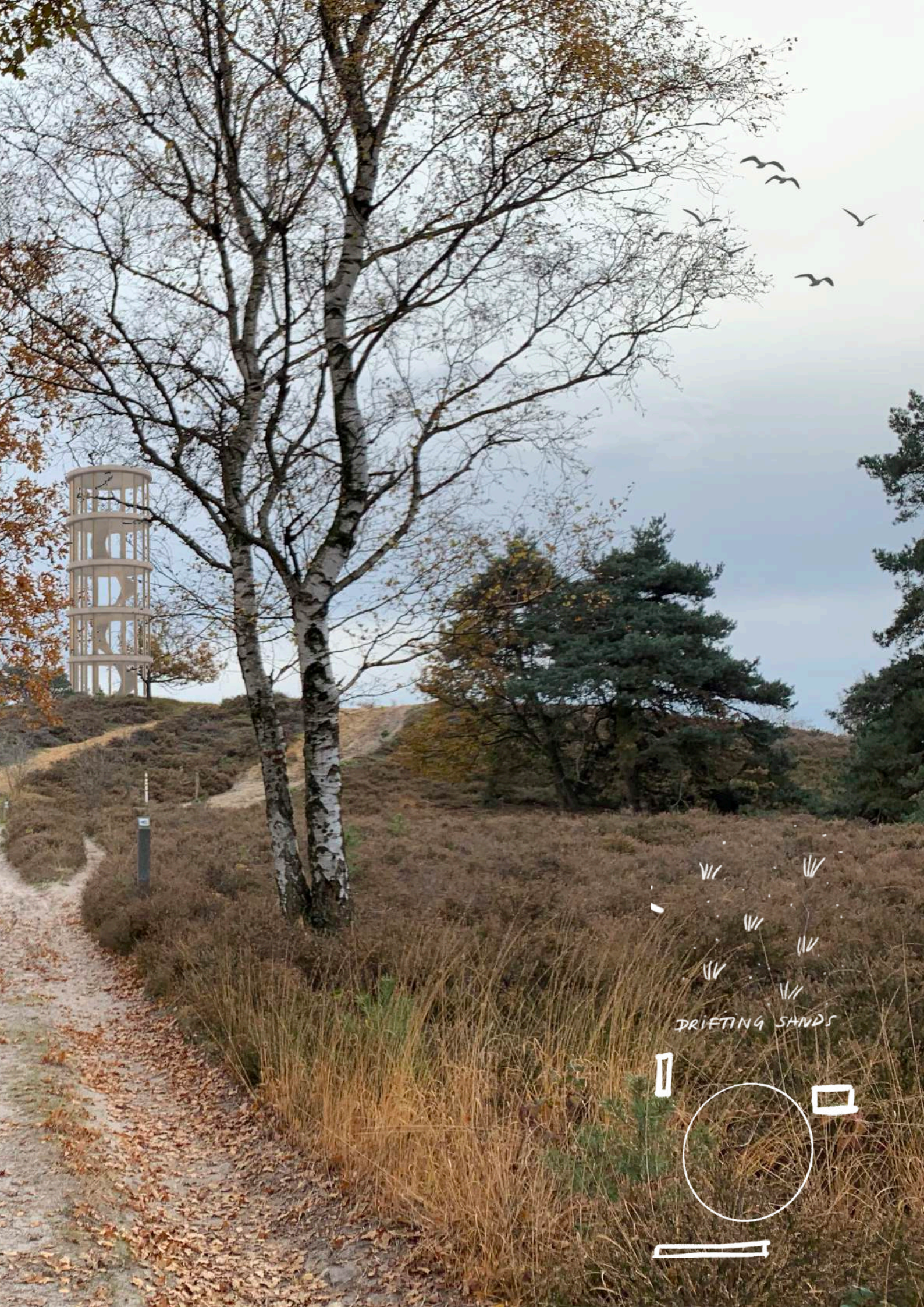


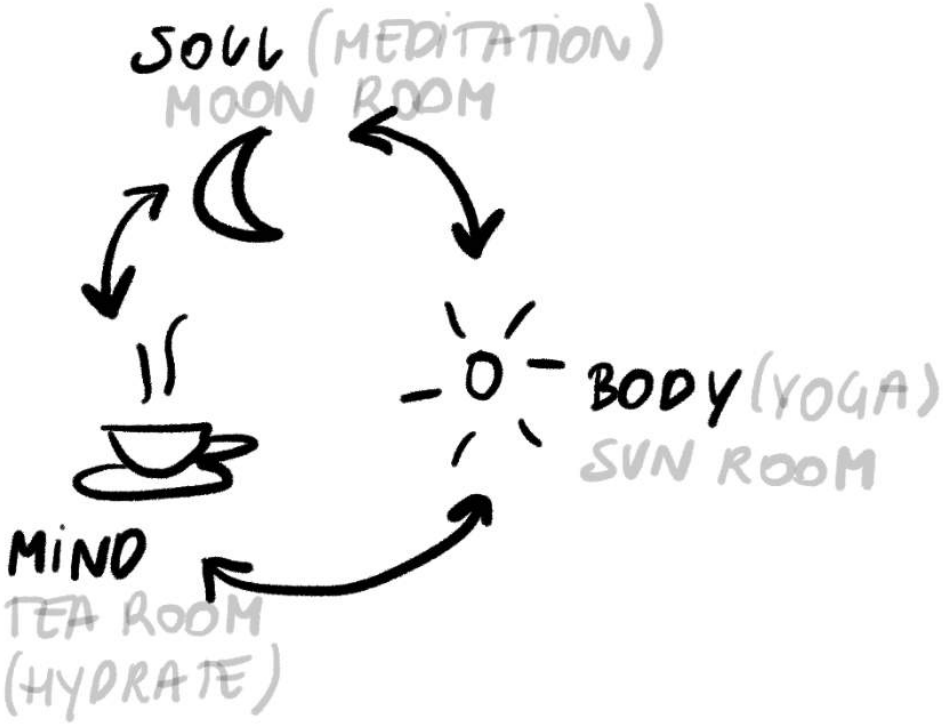
Visitor's Centre Nature Reserve
Bo Westerlinck

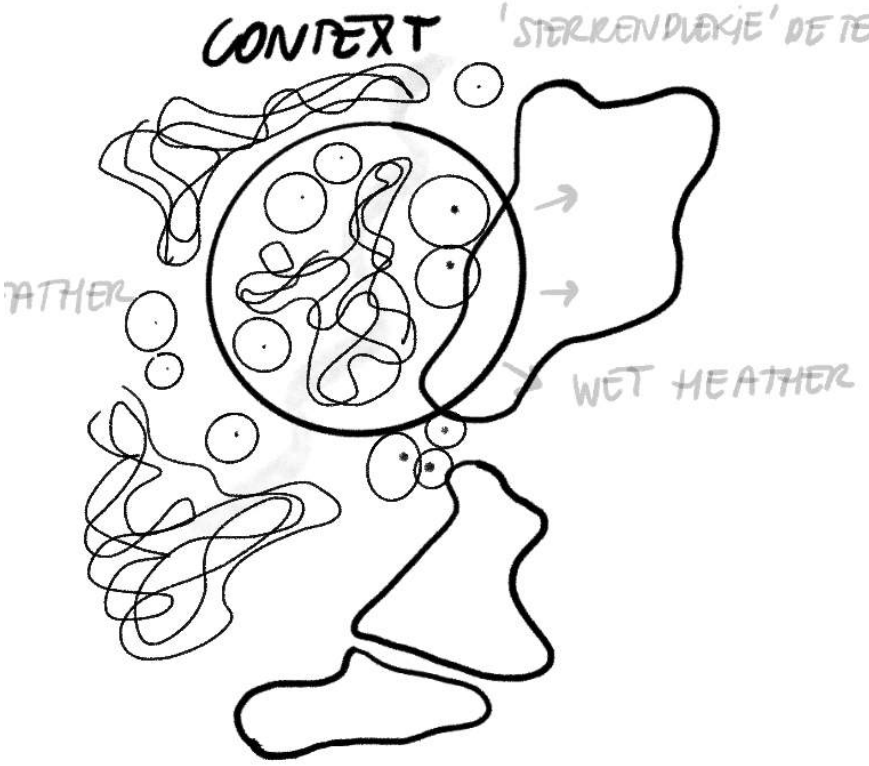


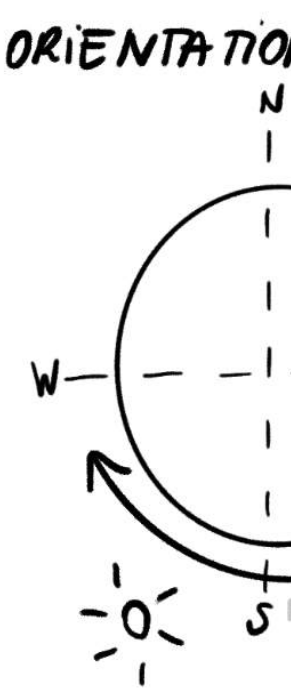
Visitor's Centre Nature Reserve
Bo Westerlinck

LANDSCAPE PROJECT / STRATEGIES
CONCEPT
VISITORS' CENTRE/CAFE
ELEVATED BOARDWALK
WATCHING TOWER
PONTON / PLATFORM
ELEVATED BOARDWALK
WALKING PATHWAY
RESTING / STRETCHING AREAS
LOOKOUT SPOTS/ BIRD WATCHING
ELEVATED BRIDGE OVER LAKE
ELEVATED BETWEEN TREETOPS
LOOKOUT POINT / ELEVATED PLATFORM


DRIFTING SANDS


SOUL (MEDITATION)
MOON ROOM
BODY (YOGA)
SUN ROOM
MIND
TEA ROOM
(HYDRATE)


CONTEXT
'STERRENDUIKJE' DE TEUT
ATHER
WET HEATHER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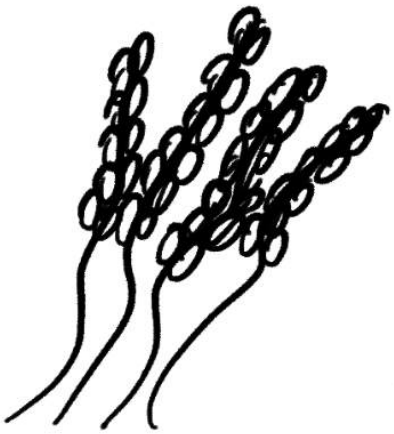


NATURAL BENEFITS OF LAVENDER

+ PROMOTES RELAXATION
+ IMPROVES SLEEP
+ REDUCES BLOOD PRESSURE
+ ANTISEPTIC + ANTI-INFLAMMATORY
+ RELIEVES PAIN
+ ...

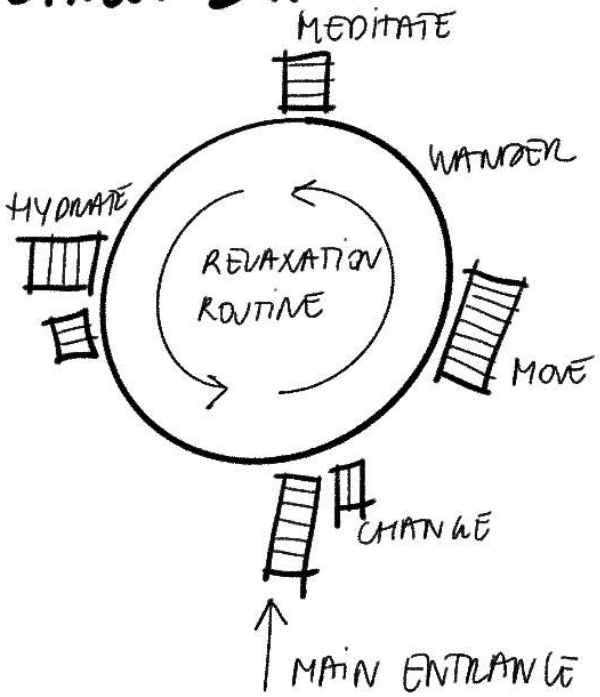
N

MAGNETIC NORTH EARTH → MEDITATION: ALIGN WITH MAGNETIC FIELD PLANET

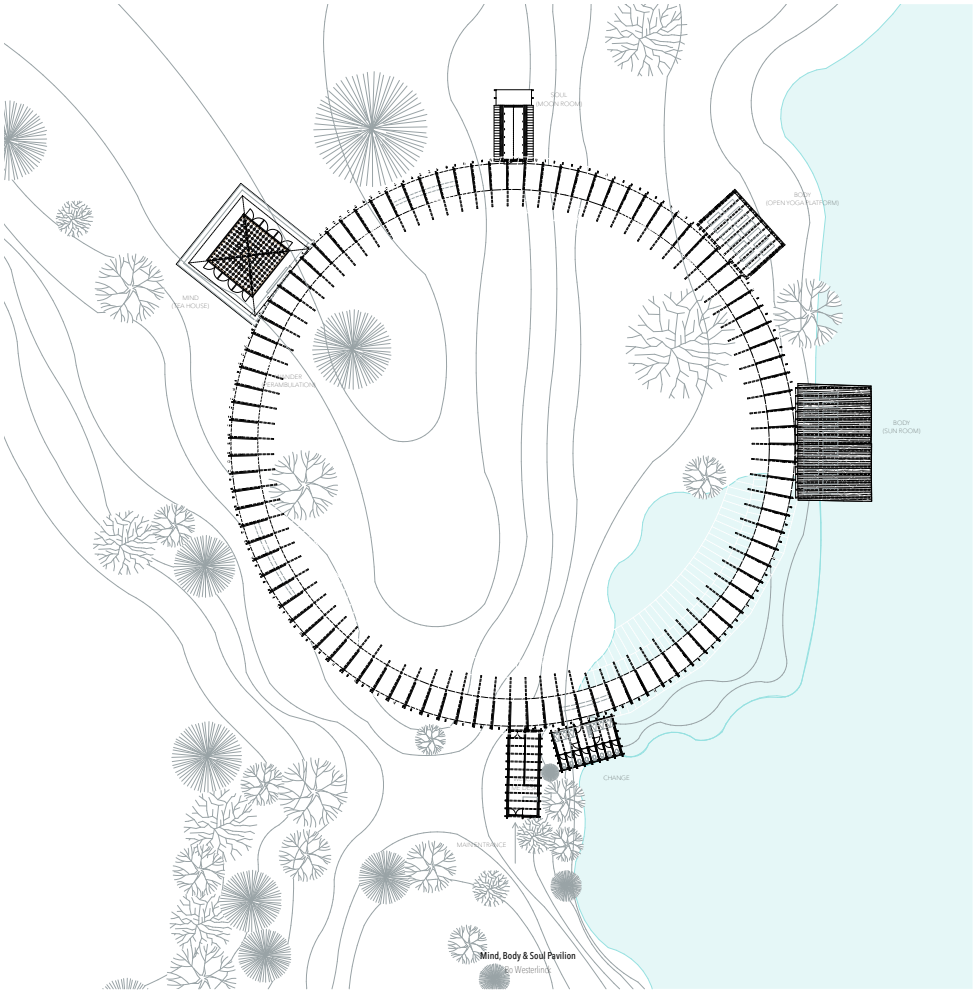
E → ENERGY YOGA + SUNRISE

MAGNETIC SOUTH EARTH

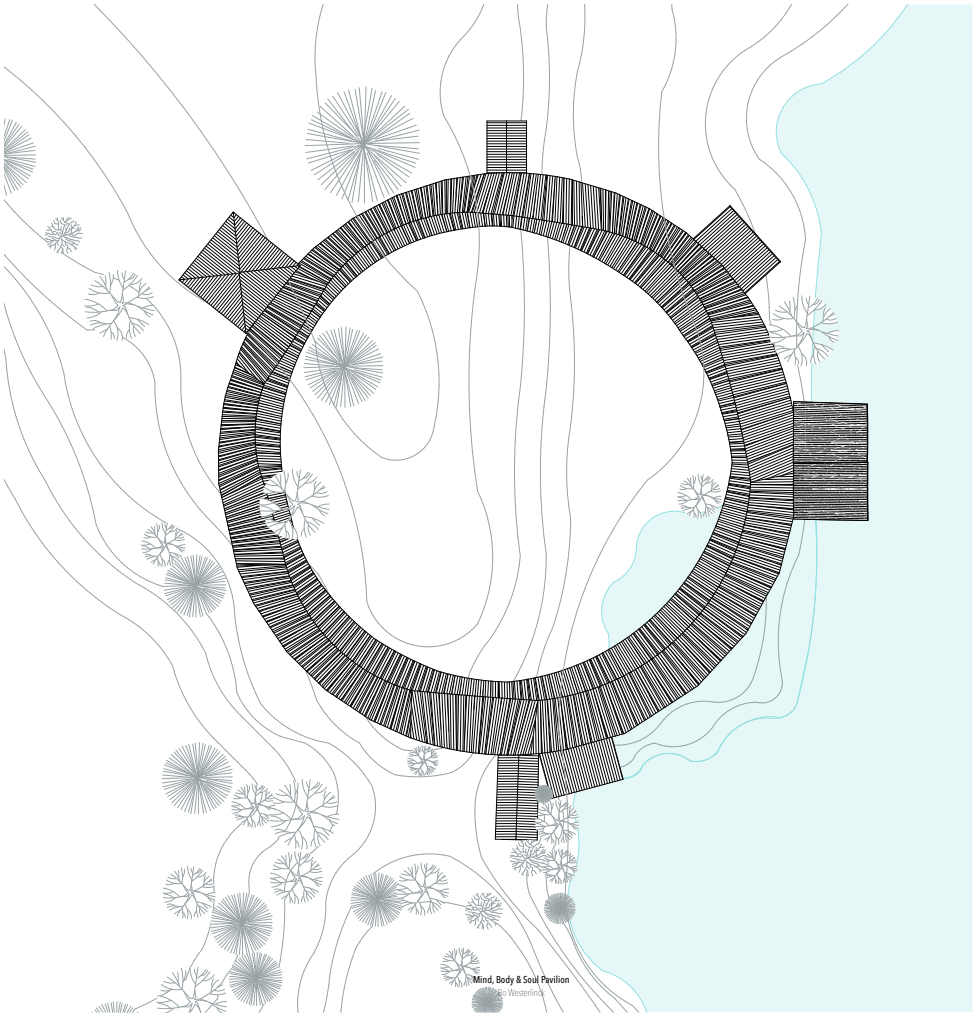
SPACES & ACTIVITIES



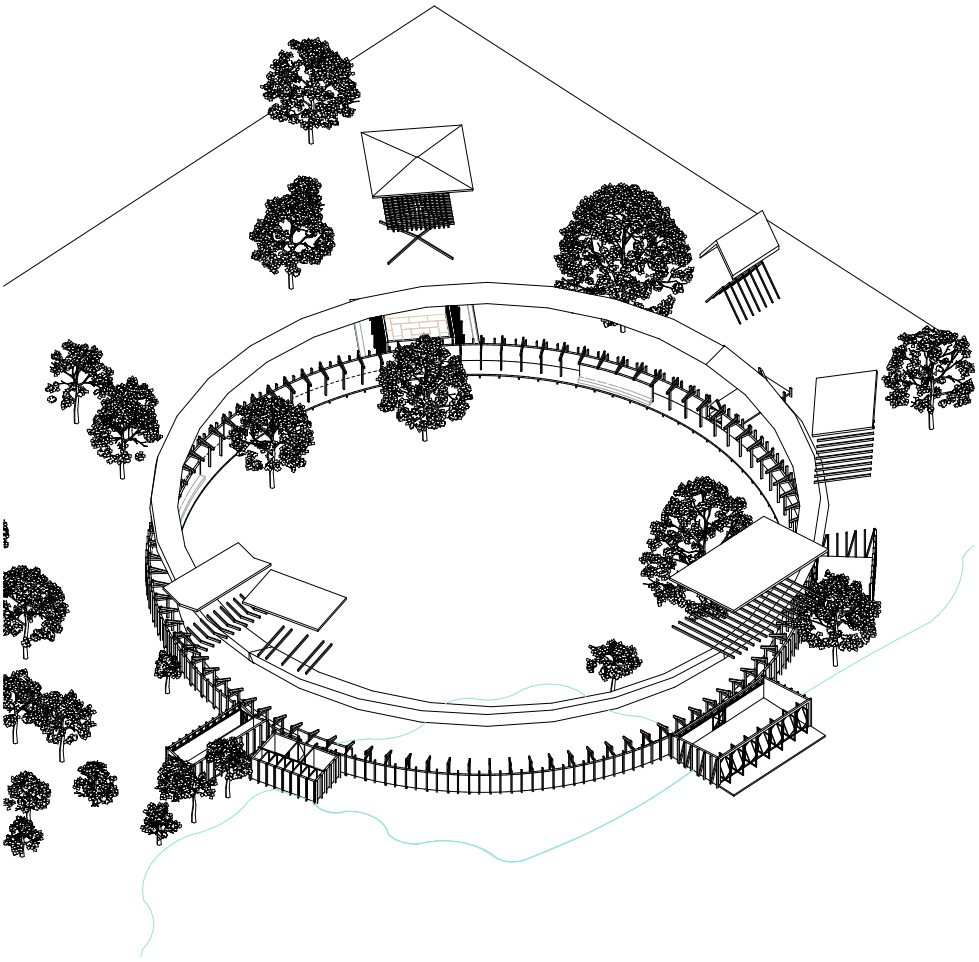

LAVENDER BUSHES

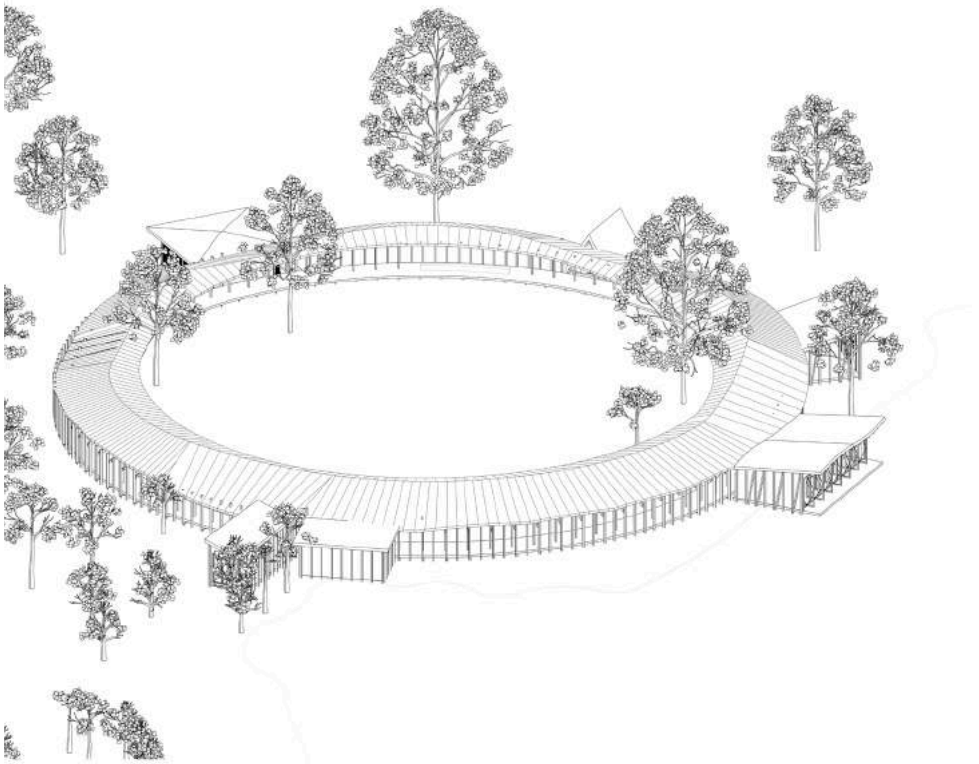


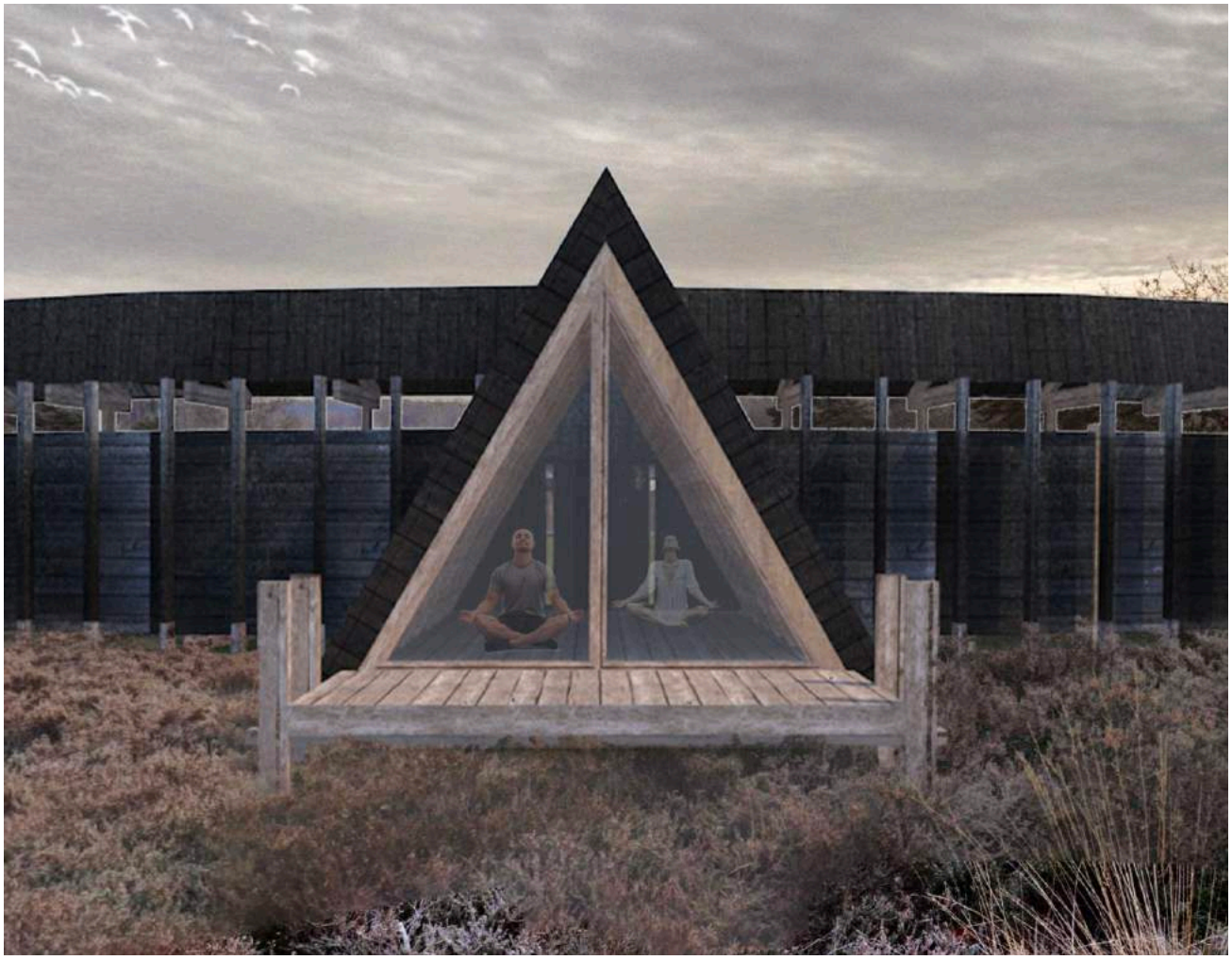
Mind, Body & Soul Pavilion
Ecco Westerlinck



Mind, Body & Soul Pavilion
Ecco Westerlinck







CONCLUSION OWN MASTER PROJECT

There are several things that we can conclude from this case study of my own master project. First and foremost, designing with these discussed principles such as, pattern(languages), parametricism or artificial intelligence, is mainly a mindset of the designer that uses them. Within this systematic mindset it is possible to experiment with these techniques, this can be done with the assistance of a computer or can also be done without using any technology at all.

After employing this mindset a thorough analysis of the entire area is carried out, this on meso, macro and micro scale. When doing this, I tried to create my own pattern language to represent my site research in a very graphical way, like Christopher Alexander himself (1977), and identified the missing patterns in this environment of Houthalen-Helchteren. This research is based on observations and interviews in order to get the complex reality the best.

Subsequently, I tried different approaches of how to deal best with this nature reserve (hybrid building, community gate, separate pavilions...) . But designing an overall design strategy first and afterwards implementing sensitive interventions on strategic places within this creates the most cohesion in the final project.

Considering that the previous discussed techniques are always focussed on an urban or built-up environment, except only a few authors like Kevin Lynch (1960). Thus I challenged myself during the design process to see if I could convert the parameters I found in nature to a certain architectural principle within my project in order to create new forms of human-nature intelligence (Latour, 2004). In the previous chapter I gave an overview of how this guided the design process towards the outcome and what things I took into account when using these instance design patterns.

Although these principles help to follow a logical design process, it always remains a balancing act between the generic and the specific. With the generic I mean precisely this abstraction of the natural environment into natural patterns, which makes it very easy to experiment with which architectural principles can respond to this, thus creating a certain interaction between human, nature and architecture (Price, 1976). But on the other hand, the specificity of the environment cannot be left out of this kind of universal system. It is very important to take this into account during the design process if one wants the architecture to blend into the specific natural location. Sometimes I got the remark that I was too focused on the side of the generic, because of course I wanted my design research to be in line with my thesis and clearly show what the possibilities were when using these rather generic systems.

We can therefore conclude that the possibilities are endless when one, as a designer, uses this rather generic or systematic mindset, both in an urban and natural context, with or without the use of technology. However, the way in which one uses this, experiments with it and why one makes certain choices during the design process remains influenced by personal values, education, culture, morality, etc.,... For this reason it is very important to communicate transparently about the different steps and choices one has made for certain design patterns during the parametric design process. In this way others can further experiment with this or adapt it to their own preferences, which creates a new form of design intelligence.

MAIN CONCLUSION

From the first chapter Pattern Languages we can conclude that the main purpose of using design patterns within a system or a pattern language structure is to enable designers to follow a logical design process in which the patterns are converted into empirical projects and all aspects are combined into one qualitative overall design (Alexander, 1977). But if one really wants to make use of this as a designer, it is crucial to gain insight into the various critiques that have appeared on the subject, as well as Alexander's whole body of work (1977), and finally to understand the main structure in which these separate patterns are placed and the relationship between the patterns themselves.

Within the second chapter Parametricism we can conclude that it is merely a mindset that should be used by a designer in order to facilitate experimenting with these design patterns. Different authors have done this in very diverse ways; more sculpturally as a formal experiment (Hadid, 1993), more focused on the role of the architect as a social experiment (Price, 1976) or as a technological experiment (Bernstein, 2000; Rutten, 2017).

The third chapter about Artificial Intelligence, could provide a next step in assisting this parametric experiment with design patterns. Nowadays this is not used as much within the architectural sector in general, compared to other sectors we are lagging behind (Retsin, 2019; Hu, 2017), but this technological intelligence could offer enormous possibilities in the future to support the architect during different steps of the design process (Negroponte, 1970).

Furthermore, communicating very transparently why certain choices where made during the design process, is a lot more valuable than trying to create a generic solution with a universal logic for every design challenge. This is a constant balancing act between the generic and the specific. In this way we can achieve new forms of intelligence like human-nature intelligence (Latour, 2004) or design intelligence for others to continue to experiment with this.

How one then uses/transforms the discussed techniques remains something very personal, considering that every designer has its own values, preferences, education, culture, habits, etc.,... Exactly because the possibilities are endless, it is extremely interesting and valuable to experiment with it as a designer, and to learn from others who have done it in another special way (Steenson, 2017).

As already mentioned, these discussed techniques mainly focus on a built or natural environment, but it's also possible to transform or adapt these to a natural environment as a designer. In my own case study I challenged myself to first identify these natural patterns and afterwards how to transform these into different architectural patterns/principles. The different experiments and decisions made throughout the design process are explained in order to achieve a new form of design intelligence and hopefully inspire other designers to use similar techniques as a way to guide their design processes into empirical projects.

Consequently, within this theme of Architectural Intelligence, we can also ask ourselves how other designers would identify patterns and then, always with the balance between the specific and the generic in mind, transform them into architectural patterns? Or how the previous experiment, in addition to the social and formal experiment, could be supported by using innovative technological systems?

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Figures, sketches, diagrams, renders and plans of own production, Bo Westerlinck, 2020.

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