



Biodiversity Positive Attitudes

encouraging a biodiversity positive future by providing perspectives for action through a nature education platform for primary schools

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Abstract

In this thesis we explore how digital educational products can foster biodiversity positive attitudes in children aged 10-12. With it it aims to contribute to the broader societal transformation necessary for ecological sustainability. The project aligns the strategic goals of the main stakeholder, Naturalis Biodiversity Center, with a more than human design perspective. By doing so this thesis aims to contribute to the education department of Naturalis by providing meaningful insights for the development of educational products and a promising concept direction: the N=ZIEN platform. A platform and physical device meant for primary schools to learn about the ecology in the local area of the school. Through the narrative of citizen science, pupils are engaged to catalogue nonhuman encounters and identify them in a chat environment. Based on these sightings a final lesson ties all sightings together to build a web of life for the environment. On the other hand, the thesis makes a contribution to the design discourse by introducing the concept of a keystone citizen, a reframed user to fit more than human ambitions. The ideals behind the keystone citizen draw heavily from constructionist education theory and in particular a model for transformative learning (Head, Heart, Hand model). Based on the keystone citizen a design framework is presented on how to design for a biodiversity positive attitude. Finally, the conceptualisation of and reflection on the N=ZIEN platform is documented to serve as a case study on how to apply the framework in a real world context. Ultimately, this thesis advocates for the design of products, educational and other, that contribute to shaping a society that is desirable and sustainable.

Acknowledgements

In this paragraph I would like to express my gratitude for all the people who have made this individual project a collaborative effort. Starting with my supervisory team from TU Delft, Caiseal and Ianus. I owe a lot of the quality of this thesis to the continuous support of Caiseal. On several occasions she has helped me structure my thoughts and prioritise my activities. While Ianus provided inspiration and refreshing perspectives enriching the approach. On the side of Naturalis I would like to thank Leonie and Hansjorg in particular for their great support. Leonie has truly made this project valuable beyond the academic discourse by inspiring me and helping me embed the project more in the organisation. On the other hand Hansjorg has helped me shape my understanding of the different insights and the multiplicity of the topic through his thought provoking questions. I would also like to thank the rest of the education department in welcoming me and helping me out wherever I needed. I would also like to thank my friend Lars for being a much needed buddy in the process of graduating and helping me out with workshops and insight synthesis. Thanks to Eva and Suzanne for proof reading my sometimes long and unstructured sentences and thank you to all the experts and participants willing to lend me some time to pick their brains. Furthermore, I am appreciative of the many people who have helped in making this thesis ever so slightly better through the coffee chats. I would also like to acknowledge the use of ChatGPT as it was instrumental in identifying relevant fields of study, structuring my thoughts and, as will become clear, in prototyping chat interactions. I would like to express my appreciation for two books which have helped me create the visual identity of this thesis. The first being a Japanese book about colour combinations, which has helped, to some extent, to overcome my colour blindness (青幻舎第二編集室, 2010). The second being Grid systems in graphic design (Müller-Brockmann, 1996), a wonderful book providing some much needed support in the expansive world of graphic design. Finally I would like to express my gratitude to Fien, my partner, as she has supported me through the whole process by pulling me out of unconstructive thoughts and encouraging me to see the accomplishments.

We did it,
thanks!

Glossary

antropocentrism	The belief that humans are the central entity on earth (Forlano, 2017).	problem statement	A statement describing a (strategic) opportunity for design by encapsulating design research on a particular complex problem (Roozenburg & Eekels, 1995).
biosphere	The system that is made up from all of the organisms on earth.	prototype	A manifestation of (part of) a design concept that seeks to test, evaluate and answer assumptions that were made during the design process (Buxton, 2007).
constructionism	An education philosophy that emphasises the need for effective engagement in order to construct personally relevant knowledge and gain meaningful insight into the world (Papert et al., 2002).	science in the making	Describes the way science is made. It is uncertain, happening now and full of assumptions (Latour, 1987).
design goal	A statement synthesised from design research that dictates what the to be designed product needs to do.	sketch	A manifestation of (part of) a design concept that seeks to question, evoke and open up ideas surrounding the design (Buxton, 2007). Note that sketches in this sense are not tied to paper drawings, but can also be for instance fabrications, enactments or annotations.
ecological literacy	Knowledge and understanding of the earths life-giving systems (Pitman et al., 2017).	ready made science	Describes science that is presented in an organised, factual and clean manner which appears linear and objective (Latour, 1987).
food web	a schematic describing which species eat which other species.	vegetation	Is the sociology of plants, describing groups of plants that naturally seek eachother out. These constellations are in constant development and can evolve alongside humans (Schaminée et al., 2022).
humanism	A human-centered philosophy that emphasises agency and encourages scientific reasoning (Forlano, 2017).		
keystone species	A species that has a disproportionate effect on its surroundings compared to the percentage of biomass that species makes up in that system (Worm & Paine, 2016).		
more than human design	A design perspective that draws from posthuman ethics, embraces all organisms as stakeholders and acknowledges the agency of nonhuman organisms and technology (Rosén et al., 2024).		
nonhuman	Other than human organic and inorganic subjects, particularly by framing them as something with agency (Forlano, 2017).		
perspective for action	Guidelines on what a person can do and how they should behave in certain situations (Afdeling Buitengewone Zaken, 2022).		
problem definition	A design methodology proposed by Roozenburg & Eekels (1995) that provides structure to describing a complex problem from different perspectives in order to gain in-depth knowledge about its workings.		<p>It serves to make a distinction between education and learning. In this thesis with learning I refer to the act of acquiring knowledge. While education encompasses learning, but ultimately describes the larger process of becoming educated, or attaining a certain personhood.</p>

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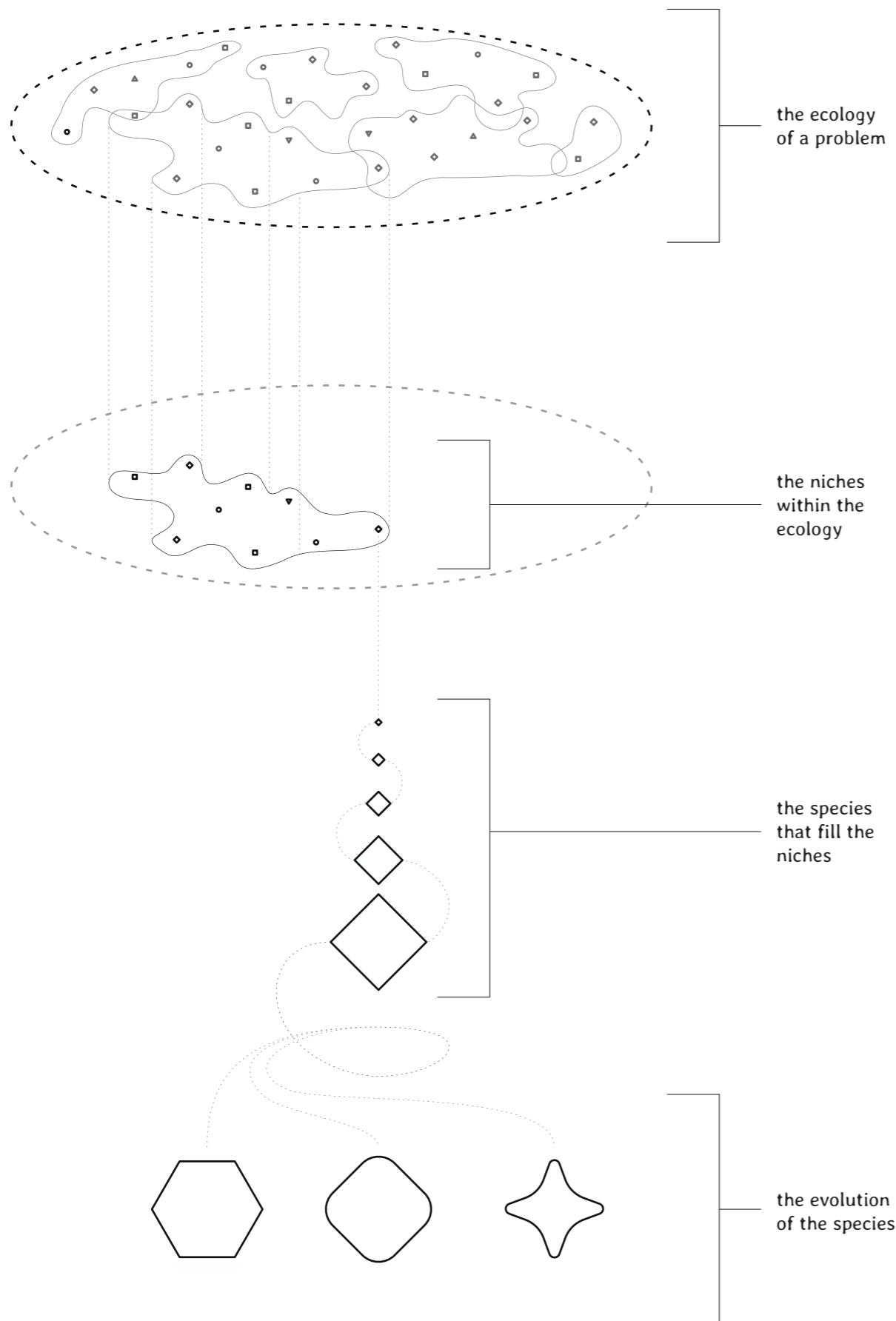
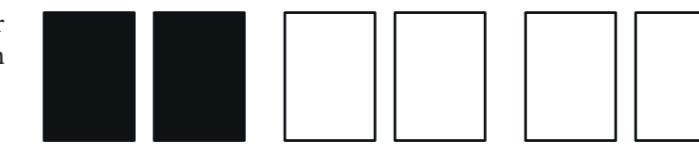


Figure 01. a schematic explaining the chapter titles

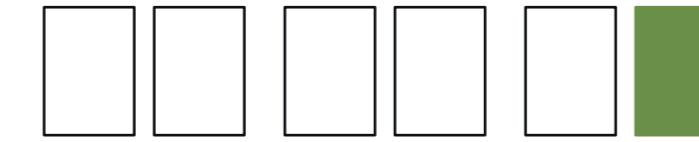
Reading guide

This thesis is structured in five chapters. Each chapter starts with a chapter introduction, which can be recognised by its black pages. Here an overview of the chapter is described. All chapters also end with a chapter conclusion in the corresponding chapter colour, answering the related research questions.

chapter introduction



chapter conclusion



The glossary and chapters are colour coded on the top right of the spread. Below you can find an overview of the different colours corresponding with the chapters. Some words throughout the thesis are made bold on introduction. This is to indicate that they are indexed in the glossary.

- █ Glossary
- █ Chapter 01: Introduction
- █ Chapter 02: Ecology
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Introduction

Setting the stage

Project origin
Objectives
Research Questions
Project approach
Chapter conclusion

This thesis is a voyage into a world where education philosophy, more than human design and transformational societal change meet. We explore the structure of this vast landscape by looking at it from different abstraction levels. Here the ecology chapter serves as a zoomed out view of the forces at hand, the niches chapter investigates potential opportunities, the species chapter investigates ways to fill those niches and finally the evolution chapter speculates about how this project may evolve and find its way into society. However, before we dive into ecology, this chapter aims to set the stage, introducing the main stakeholder, the underlying design theories and the research questions.

Figure 02.
"Floresta
virgem do
Brasil" a
burin showing
the forntier
of brasil by
Claude-François
Fortier (ca.
1822)



Project origin

Already for two centuries has Naturalis existed as a natural history museum. The intention behind exhibiting the collection has changed throughout time from instilling fascination for nature to falling in love with nature. With the new strategic plan for 2025-28 Naturalis aims, not only to encourage care and admiration for the natural world, they also want to play an active role in the societal transformation that is necessary to construct a biodiverse future for the Netherlands (Naturalis, 2024). Naturalis engages with society in roughly four domains which all have different affordances when it comes to shaping this future (Figure 03). However for this particular project the digital branch of the education department has reached out to investigate how to provide **perspective for action** to their consumers. According to the social design agency Afdeling Buitengewone Zaken we can define perspective for action as pointers that tell people what to do and how to behave in a certain situation. It is in this what and how that this thesis contributes in both the education environment and the academic discourse.

Figure 03.
activities of
naturalis

Objectives

The objectives of this thesis come in twofold. Foremost a contribution is made in the form of a design project in collaboration with the education department of Naturalis Biodiversity Center. Second, the thesis aims to contribute to the discourse of more than human design by providing reflections on the project from a design perspective with the process of this project as case study.

Project brief

The following project brief was formulated as starting point for the collaboration with Naturalis Biodiversity Center:

The education department of Naturalis Biodiversity Center is looking for an enhancement of the digital product portfolio to provide users with frames for action outside of the museum in order to help them in developing a biodiversity positive attitude.

Although this statement aids greatly in scoping the project, defining the activities that need to be conducted and the kind of contributions that will be made, it does not dictate the manner in which this is done. Looking at this statement we can rephrase it as an enhancement of the digital product portfolio that both provides frames of action as well as aids in the necessary societal change for a biodiverse future. In this sense, the thesis will set out to contribute to this brief in threefold:

- It will provide a thorough definition of what a biodiversity positive attitude entails
- It will explore a multitude of concept directions to investigate which avenues have potential
- It proposes an enhancement of the digital product portfolio based on the insights from the other two contributions.

Design discourse contribution

Four contributions are made to the (more than human) design discourse in this thesis. The thesis presents a framework for designing for biodiversity positive futures by looking at the ideal citizen. This potential user is described by ideals and interactions rather than demographics as is the norm in user centered design. It is in this rephrasing of what the user can be that this thesis may provide new insights in what it means to design in a more than human fashion.

Related to it is the second contribution in the form of a reflection on a design process that combines a more than human perspective with a user-centered approach. Although counterintuitively these can coexist and working with them has to some degree aided in maintaining a more-than-human voice throughout the project without allocating an external more than human advocate.

Furthermore, the third contribution comes in the form of the design aspect of this project. It functions as a case study for bringing more than human design into practice both in a non academic setting as well as in manifesting products.

Finally, the thesis contributes in the field of design for behavioural change with an ethics reflection on designing for becoming. This has elements of behavioural engineering scattered through it, which can be considered unethical. In a final reflection an overview of different voices is represented

Research questions

this thesis investigates transformational societal change with regards to biodiversity positive attitudes and how education can play an instrumental role in facilitating this through digital means. Reformulating this into a research question that has benefit for Naturalis, the education discourse and the design discourse we get:

'How can digital educational products, designed from a more than human perspective, foster biodiversity positive attitudes to support transformational societal change?'

However to be able to answer this research question we need to break it down into smaller components. This thesis document builds up to answering the main research question in the final chapter, by answering sub research questions. Here we follow along with the earlier introduced analogy of **ecology, niches, species** and **evolution**. Where in the ecology chapter we investigate the underlying principles; In the niches chapter we investigate opportunities; In the species chapter we investigate how to materialise; and finally, as mentioned before, in the evolution chapter we answer the main research question and assess the fertility of the different contributions. To the right you can find an overview of the different research questions and in which chapter they are answered.

RQ1	<i>How can digital educational products, designed from a more than human perspective, foster biodiversity positive attitudes to support transformational societal change?</i>	p.XXX
RQ2.A	<i>Why should we invest in developing a biodiversity positive attitude?</i>	p.XXX
RQ2.B	<i>What are the fundamental forces and principles that prohibit a biodiversity positive society right now in the Netherlands?</i>	
RQ3.A	<i>What does a biodiversity positive future look like?</i>	p.XXX
RQ3.B	<i>How can we design for the development of a biodiversity positive attitude in 10-12 year olds?</i>	
RQ4.A	<i>How can the unique resources of Naturalis contribute to the design of (digital) artefacts for 10-12-year-olds in the Randstad to foster a biodiversity positive attitude?</i>	p.XXX
RQ4.B	<i>How can we apply the keystone citizen framework to design artefacts that complement and encourage the development of a biodiversity positive attitude?</i>	

Project approach

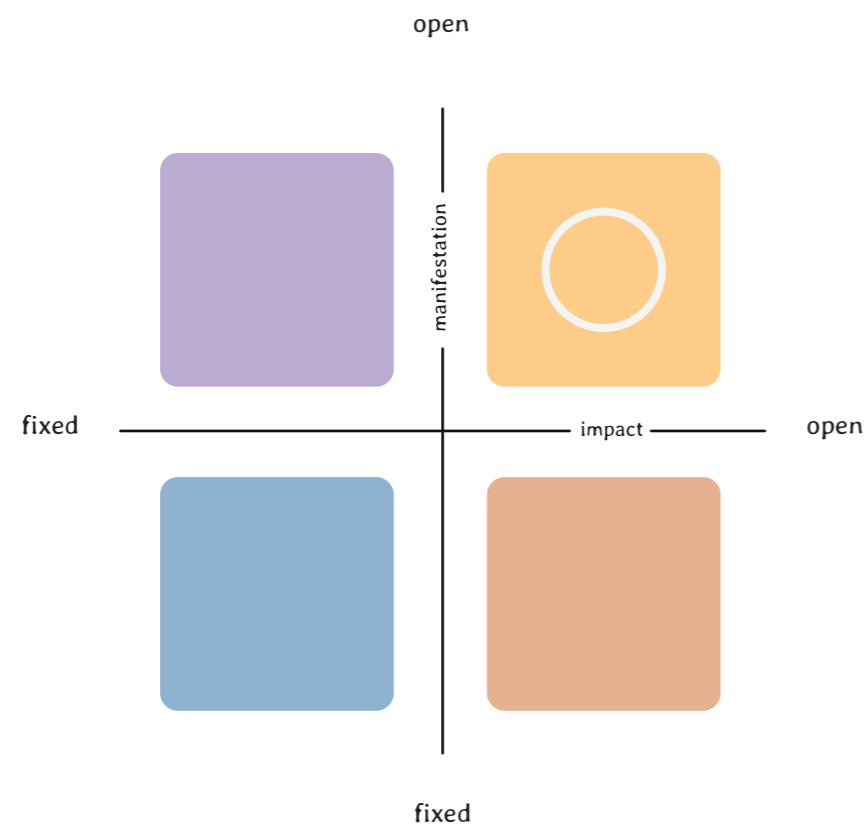


Figure 04. this project situated on the navigation canvas proposed by van Erp in the Dutch Design Guide (van Boeijen et al., 2020)

This chapter contextualises the type of project this thesis is, what kind of perspective is adopted throughout the process, what model is used for generating milestones and observing progress and which approach was used to get to the final concept.

Project type

To determine which perspective to take, approach to follow and which activities to conduct for this thesis, it is crucial to understand what kind of project this will be. Here it serves to understand the nature of a project. This basically answers the questions: How clear are we already on the activities we have to conduct and how well do we already know what the outcome will be? A way to get an indication of this is the Navigation Canvas (Figure 04), which defines four quadrants based on whether the impact and manifestation of the outcome are open or closed. Where the impact refers to what added meaning the design brings to people's lives and manifestation is about how clear we are on what it will look like. Although the initial question posed by Naturalis does give an indication of the impact and manifestation, it does not make them explicit. On the one hand the outcome should have a positive impact on biodiverse behaviour in the form of a biodiversity positive attitude, but what this means is yet to be defined. On the other, for the manifestation we are looking for an educational product, but what form this takes is still open. According to van Boeijen et al. an open impact and open manifestation project calls for the designer to look beyond the now and take a stance on the future (2020). By formulating a vision it helps to understand what we are working towards. We can do this by defining the manifestation and impact further.

Design perspective

Throughout this project a **more than human** perspective has been adopted. To better understand the discourse of more than human design I consulted two design experts within the field. Here we highlight two core elements critiqued by the more than human design discourse: **anthropocentrism** and **humanism** (Forlano, 2017).

Antropocentrism

This element of more than human design questions the human-centeredness of the scientific and design discourse. In this project this means that it manifests itself as the blurring in the distinction between subject and object. Here the subject refers to something that has agency and forms relations with other subjects, while the object refers to something that has no agency and no influence (Latour, 2012). In this thesis it manifests itself in two ways. On the one hand we investigate what it means for a design project to acknowledge the agency of **nonhuman** organisms and their intrinsic value, inspired by the ideas of Tsing (2015). On the other hand what it means to acknowledge products as influencers on our worldview and actions (Latour, 1987). Although a true parliament of things is difficult to attain in the short span of this thesis, nonhuman organism needs are considered in the broad sense of interacting with biodiversity on terms that benefit both humans and the **biosphere**. On the other hand different considerations are made for the development of the educational tools in order to acknowledge their influence on the users. Particularly, Arkel & Tromp provide a framework where they look at the aesthetic, moral and contextual appropriateness (2022). This framework is used to develop the designs accordingly.

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Humanism

In addition to the critique of anthropocentrism, the more than human design discourse also questions humanism, the stream of thought emphasising human agency and human reasoning (Forlano, 2017). Posthumanism introduces the situatedness and critiques human exceptionalism (Haraway, 2016). While this thesis does acknowledge the intersectionality of humanism and the inequality of services that influence one's perspective on nature (such as greenery in the neighbourhood and parents who engage with nature activities), it is not a focal point of this thesis. However, it does find its way into the project by embracing the importance of place and situated knowledge.

More than human design in this sense is then not so much about representing the needs of nonhumans in a user centered manner, nor does it claim to run a participatory course with nonhumans. Instead it manifests itself in taking a networked perspective of our environment, relationships and interactions. As Giaccardi et al. (2024) have demonstrated, this is still a relatively new field, leading to an absence in tools, frameworks and theories. Although the body of references, projects and theories has been growing, most contributions tend to stay conceptual and academic (Rosén et al., 2024). This thesis, as mentioned before, sets out to provide a case study in designing for a human audience that embraces the conceptual shift that more than human design embodies.

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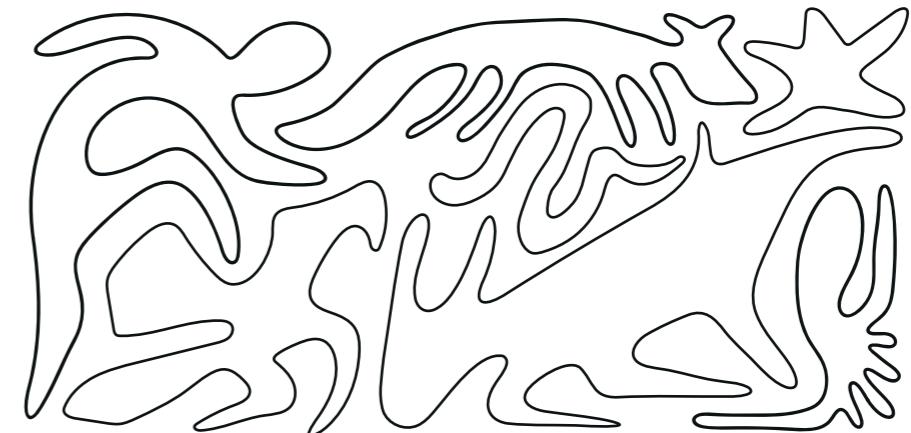
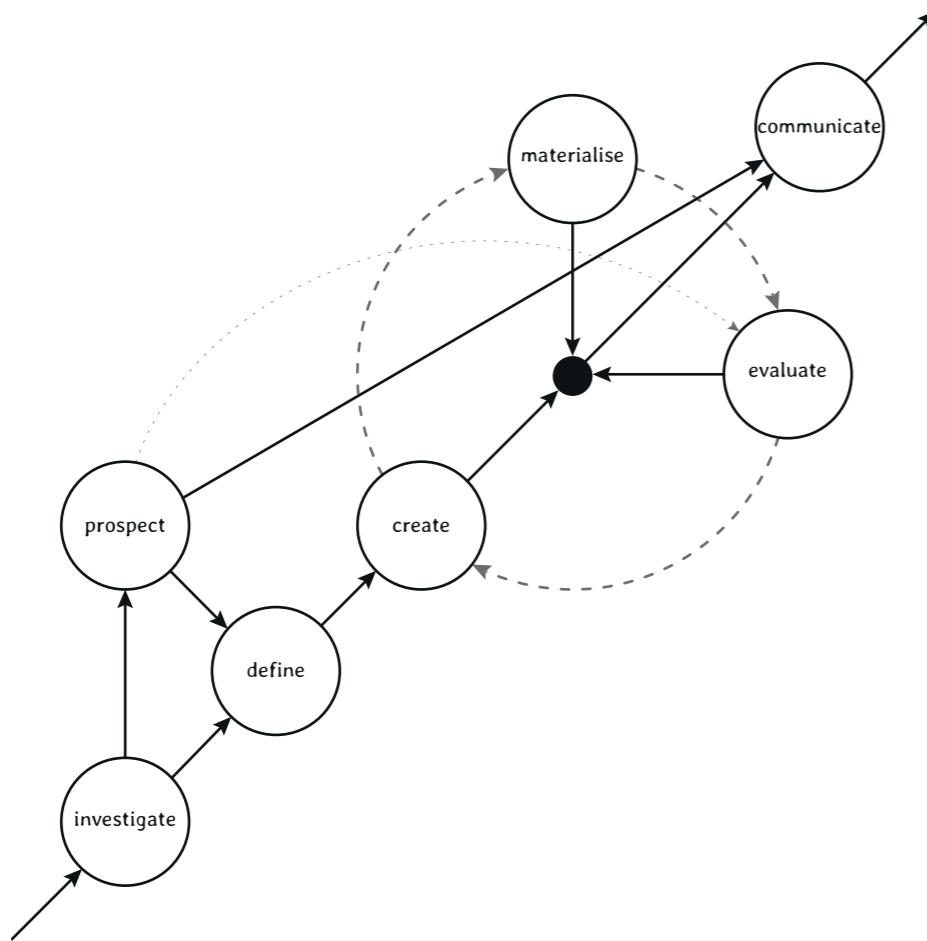


Figure 05. who do we grant agency?

Figure 06. design model for this thesis



investigating Understanding the context and underlying forces.

prospecting Imagining a desired scenario and how that guides the design.

defining Redefining the problem and formulating appropriate design goals.

creating Conceptualising designs that operate within the boundaries of the problem.

materialising Iteratively alternating between sketching and prototyping to gain deeper understanding of the mechanics of the role, aesthetics and implementation of the concept.

evaluating Subjecting the concept to evaluation with the target audience and experts.

communicating Sharing the knowledge generated by the thesis beyond TUDelft and Naturalis.

Design approach

The overarching design approach used for this project is user-centered design. This problem solving approach seeks to understand the needs, desires, properties and capabilities of projected users to create meaningful and desirable products for them (van Boeijen et al., 2020). Generally this approach is adopted when there is a gap between the designer and the user, as it aids in understanding the needs of the primary user. This approach may seem to conflict with the more than human perspective that is adopted for this project. However, it is in the shift of what is considered to be implied by the user that this project may distinguish itself from other user-centered design projects. We can marry the perspective and the approach by reframing our user as someone who is an actor in nature, rather than a master of one.

Design model

To adopt the user-centered design approach with a more than human perspective, a model derived from the basic design cycle was created (Roozenburg & Eekels, 1995). However rather than the traditional model appropriate for user-centered design projects (Figure 07). This project works with some additional steps as well as some alternative steps. By combining the frameworks for the problem definition (Roozenburg & Eekels, 1995), future visioning (van der Helm, 2008), the user-centered design approach (Norman, 2013), **sketching** (Buxton, 2007) and prototyping (Houde & Hill, 1997), a new model was made (Figure 06). First off we can make a distinction between the front-end research proposed in the basic cycle and the investigation done in this thesis. This investigation functioned more as a way to understand the societal climate, rather than the individual needs of the target audience. Due to the open nature of the project I have included the intermediate step of prospecting to translate the research insights more cleanly into the defining aspect by proposing a future vision. Instead of a prototyping phase this project was conducted doing a materialising phase where sketching and prototyping were alternated to provoke and to resolve gaps in the role, aesthetics and implementation of the final concept. Finally a communication phase is added to the model to provide the project with an afterlife by sharing the knowledge beyond Naturalis and TUDelft.

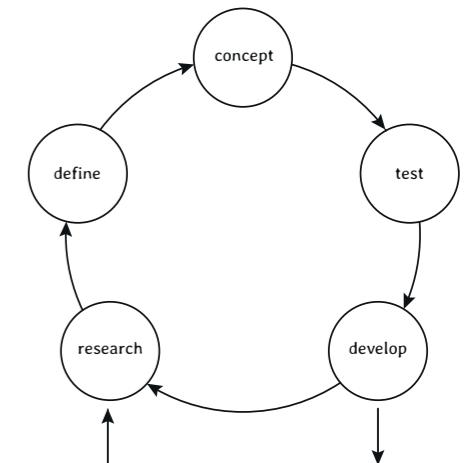


Figure 07. basic design cycle

Chapter conclusion

As this thesis aims to take along a diverse audience from both the academic and professional scene, this chapter aims to set the stage. Here we have found the reason for this project to exist in the constellation that it is and we have looked at the design theory that is fed into the project. With it I hope to have informed educators and designers alike on the goals of this thesis and its contribution to either field.



Figure 08.
Bilders painted the 'ordinary' meadows of the Netherlands unknowingly giving us a glimpse of the omnipresent culture landscapes shaped by human nature collaboration in the form of animal husbandry and the practice of pollarding willows (1860)

Ecology

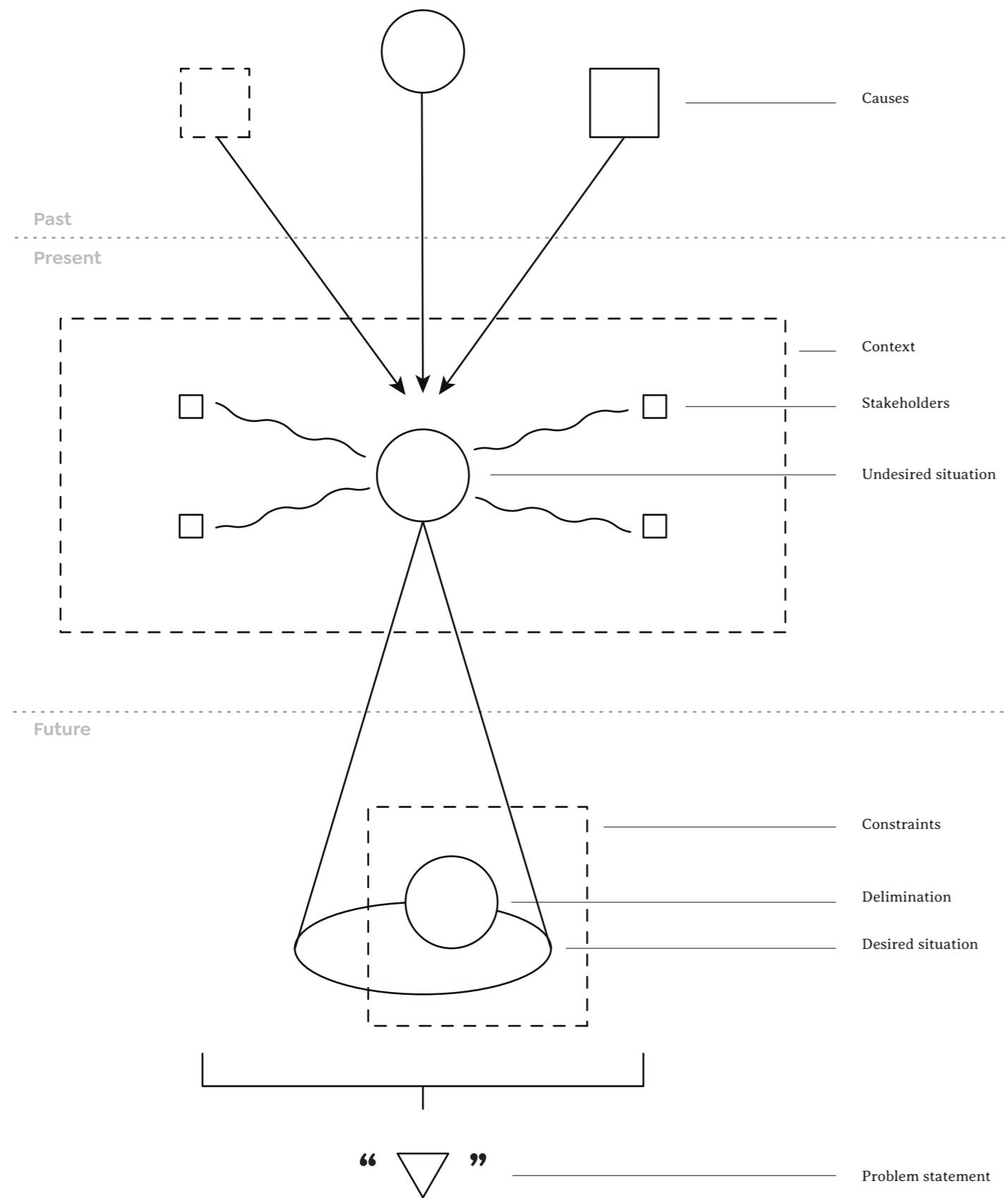
Navigating the societal forces influencing biodiversity loss

Research approach
Biodiversity loss
Situated learning
Stakeholders
Chapter conclusion

The open ended nature of this thesis project invites us to be considerate about the way we frame the problem we would like to address. Roozenburg and Eekels (1995) encourage designers to start with understanding the status quo and its continued effects if nothing changes. Here it helps to think of this chapter as mapping out the ecology within which we are operating. In this case it translates to unpacking the biodiversity crisis, investigating the relationship between the more-than-human world and humans, and developing a working definition for a biodiversity positive attitude. This chapter will address these topics by casting research insights into the Head, Heart, Hand model for transformative learning (Singleton, 2015) as it provides a framework to both introduce the current hindrances of society to develop more positively towards biodiversity as well as introducing the educational aspect of this thesis. By doing so this chapter also provides the necessary background information by answering the following research questions:

RQ2.A *Why should we invest in developing a biodiversity positive attitude?*

RQ2.B *What are the fundamental forces and principles that prohibit a biodiversity positive society right now in the Netherlands?*



Research approach

This section introduces the approach to understand the complexity surrounding biodiversity loss and designing for transformative behavioural change. This demands a deeper and more thorough understanding of underlying context, behaviours and systems that contribute to the situation. To achieve this the **problem definition** framework proposed by Roozeburg and Eekels has been adopted for structuring collected research insights and formulating a well informed **problem statement** in the next chapter (1995).

Before diving deeper into the methodology, it serves to make a distinction between the problem statement and the problem definition. The problem definition is a set of research insights that form a theoretical foundation for the design process by filling in different proverbial building blocks of the problem at hand. The problem statement on the other hand is an articulation of this design challenge in the form of a single sentence that aims to capture the breadth of research done on the topic. This means that the problem statement is part of the problem definition. A schematic view of this relation can be found in Figure 09.

This approach was chosen because it provides guidelines on how to tackle complex challenges and doing a thorough problem analysis helps in uncovering potential opportunities. This in turn is a great starting point for a user-centered design approach as it makes it easier to evaluate ideas and designs if one knows what they are trying to achieve. The problem definition framework is combined with the Heart, Hand, Head model, to further cast the insights into areas of opportunity (Singleton, 2015).

This chapter only focuses on the past and present of the model. By crossreferencing literature and expert consultations the validity of these parts and a well-informed set of areas of impact were ensured across domains. Finally, by aligning these findings with the goals of Naturalis we can ensure that the research finds societal footing while still addressing broader challenges.

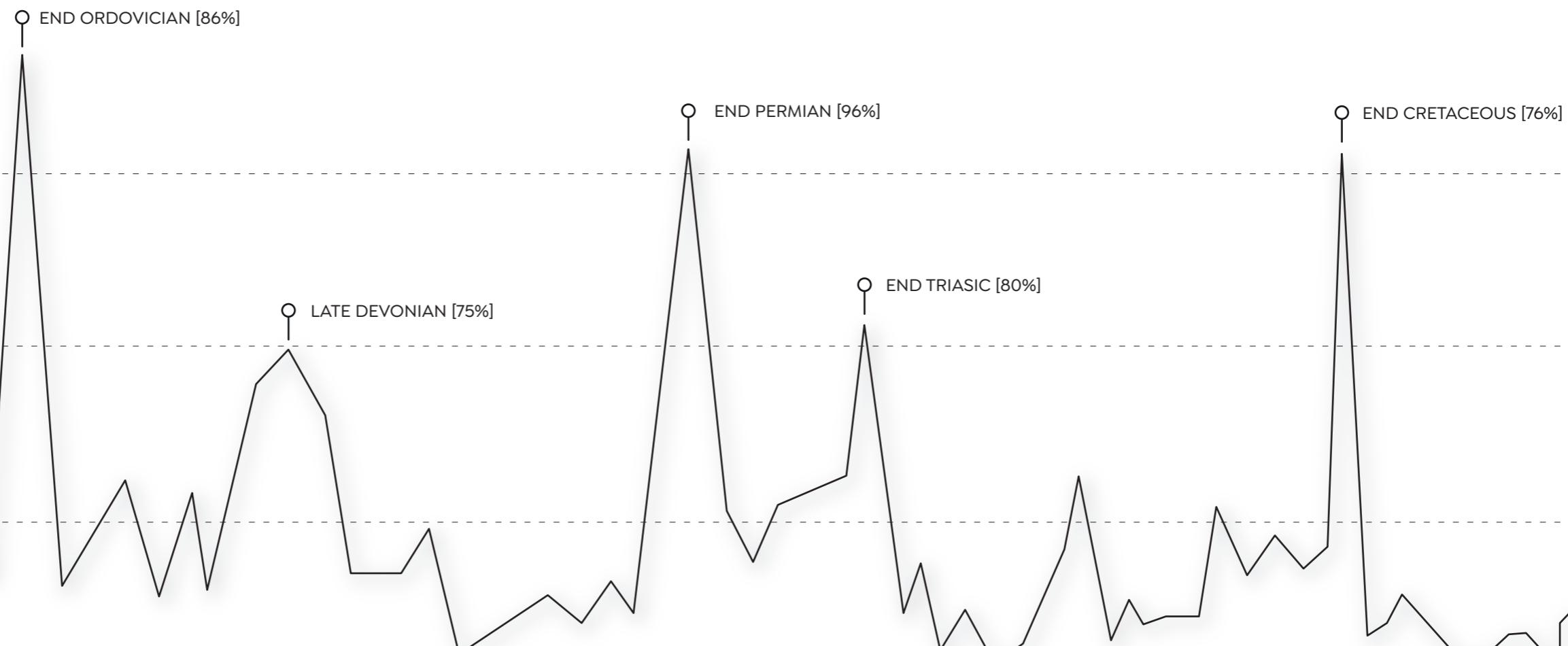
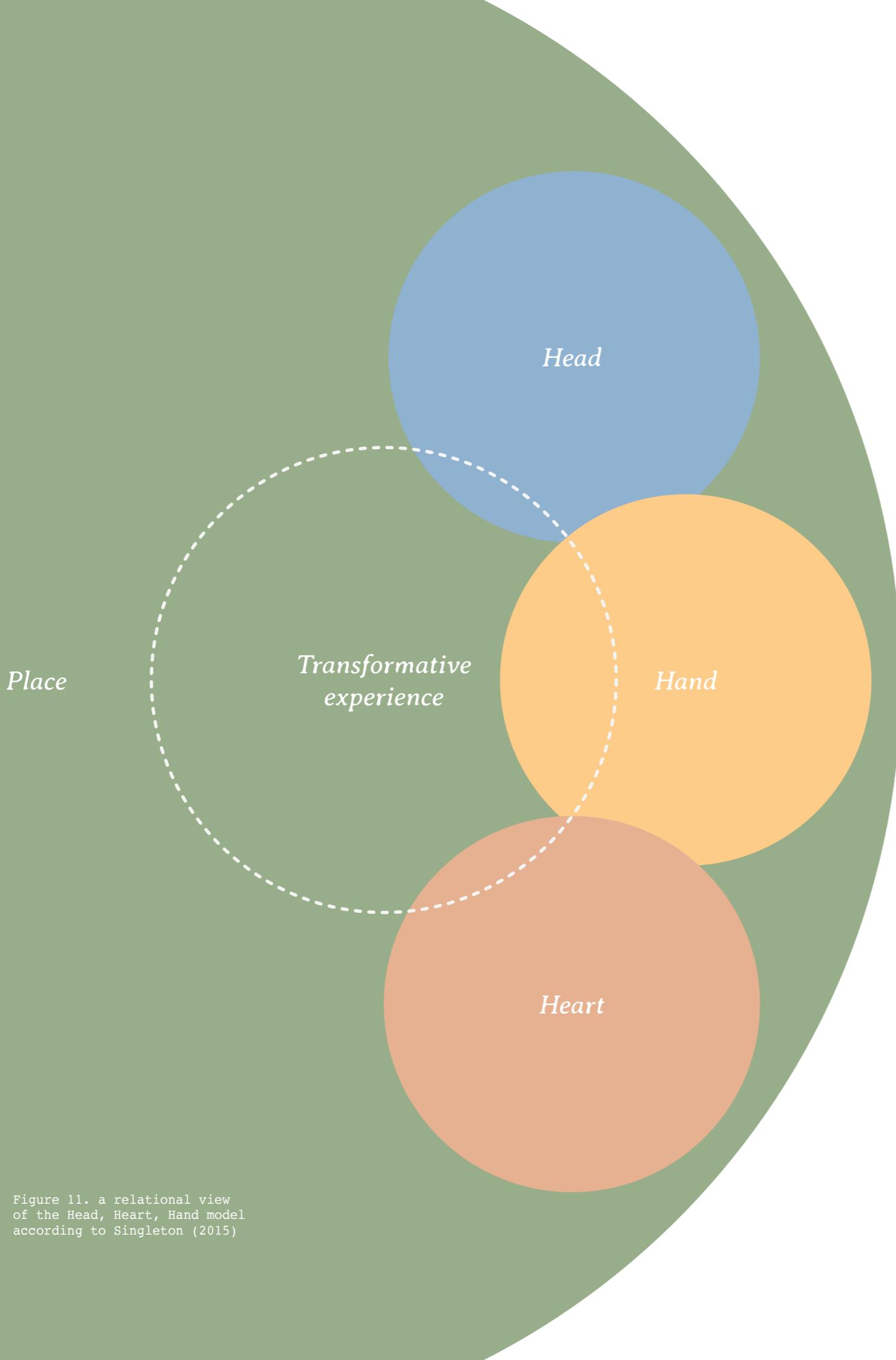


Figure 10. the five past mass extinctions and the percentage of lost species based on a graph of Ritchie (2022)

Biodiversity loss

For over 50 years we have known that human activity is influencing the workings of the biosphere and that humanity should be considerate of planetary boundaries (Meadows et al., 1972). Steffen et al. have shown us that there exists a hierarchy within these boundaries, where climate and biodiversity form the foundation of the other boundaries (2015). Others have since linked human activity to an array of global developments, one of which is a rapid loss of biodiversity: the biodiversity crisis (Richardson et al., 2023; McCallum, 2015; Western, 1992). Although researchers are uncertain whether we are facing a 6th mass extinction, they do agree on one thing. It's up to humans to alter their ways of being to prevent potential cataclysm (Singh, 2002; Ceballos et al.

2015; Swiss Re Institute, 2020; Ritchie, 2022). This suggests a need for a transformation in societal activity. However, Turner has shown that globally there hasn't been much change since the report of Meadows et al. (2008). Furthermore, scholars have also started to make this impact measurable (Steffen et al, 2015; Scholes & Biggs, 2005). However these are often incomplete and difficult for individuals to relate to. In the Netherlands Klöne & Wattimury have demonstrated that people perceive the biodiversity crisis to be less important than the climate crisis with only 16% of the adult population putting it in their top 5 concerns (2022). So while humanity has been theoretically aware of the impacts of biodiversity loss, this does not appear to be a priority.



Situated learning

The Head, Heart, Hand model provides us with a perspective on why little has changed since, by introducing us to the idea that transformation requires more than just a logical argument or emotional appeal (Singleton, 2015). The model, conceptualised for the possibility of enrichment of an experience to change a person's relationship with the world (Dewey, 1934), invites educators to consider three forms of learning (Head, Heart, Hand) to provide transformative learning experiences (Figure 11). When we look at the efforts that have been made for mitigation of the biodiversity crisis, there is a large focus on presenting the urgency. This only addresses the Head part of the model as it does not connect to observers their surroundings and sense of relation nor does it provide frames of action. Particularly, Singleton's interpretation of the model provides a perspective that is in line with the more than human philosophy of this project. Its embracement of the educational theory on situated learning by introducing Place as an important concept in transformational experience adds a degree of contextual meaning to the educational experience (2015). It is also in situated learning that we see the acknowledgement of learning as a means to become a certain person (Lave & Wenger, 1991). What this thesis strives for in becoming will be addressed in the next chapter, but for now we can say that it is about developing a biodiversity positive attitude. In the following paragraphs we use the Place, Head, Heart and Hand of the model to dive deeper into how the status quo is manifested in Dutch society. This will help us better understand what they consist of and how they inform a biodiversity positive attitude.

"Learning thus implies becoming a different person with respect to the possibilities enabled by these systems of relations."

**Lave & Wenger,
1991**

Place	Head	Heart	Hand	Transformative experience
Describes the authentic and unique environment within which learning takes place.	Describes the reflective ability to link previous experiences and share them with others.	Describes the relational understanding of knowledge and the individual.	Describes the participation in and manipulation of the physical world.	Describes an experience that allows for learning experiences that have a transformational effect.

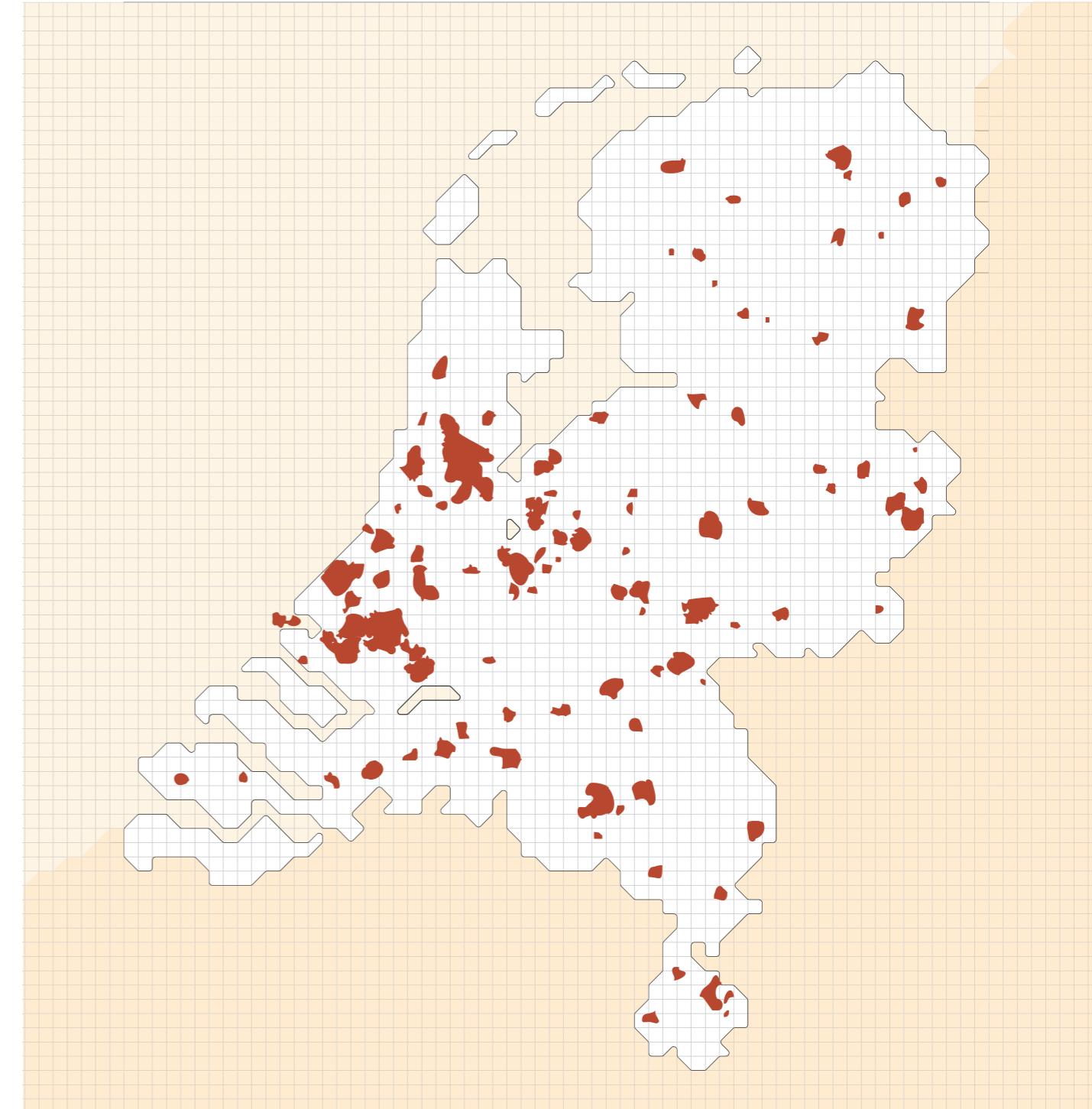


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Figure 12. A simplified map describing the urban environment in the Netherlands around 1850 [left] and 2000 [right] based on data from *AtlasLeefomgeving* (2021)

Place

The place where we interact with the world, shapes our worldview (D. Haraway, 1988). It provides an environmental, political and cultural context to all our meaningful interactions and anchors our experience (Singleton, 2015). Although there is some overlap between Place and the other concepts in the model because of its encapsulating



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nature, it serves to address it separately because of its unique significance for a transformational experience.

Addressing Place allows us to understand the context within which we want the transformation to take place. The past hundred or so years the Netherlands has developed into a place where more and more people interact with each other and the environment in an urban context (Figure 12). Pitman et al. have demonstrated that people who grow up in urban environments develop a lower degree of **ecological literacy** on average as opposed to those that grow up in rural areas (2017). An important aspect of developing a positive attitude towards the natural world (Pitman et al., 2017; Capra, 2007).

Head

Although most people have heard of the biodiversity crisis and perhaps know its urgent, but often don't understand why and in what way it relates to their experiences as we have seen before (Klöne & Wattimury, 2022). Here there are two important elements to consider: previous related experiences and interaction with others on the topic.

Our previous experiences can be used as benchmarks for future reference. These experiences are relevant on a long and short timescale. On the long timescale, we can think of the shifting baseline syndrome, where each generation subsequently experiences less nature around them and finds that to be the new normal. Actively, perceiving and reflecting on the state of the biodiversity in the local environment can make individuals more aware of shifting patterns. On the short timescale we have seen that to make sense of the world we need to engage with it (Sobel, 1999). Similarly, in one example researchers found that combining ecology lessons with zoo visits also increases nature connectedness and willingness to conserve species (Kleespies et al., 2022). It is in the facilitation of these meaningful experiences that education stands to gain.

Furthermore, interaction with others has several benefits to the learning experience apart from it being a good motivator for engagement (Silver & Robinson, 1995). Lave and Wenger argue that knowledge is best acquired through participation in social learning (1991) and Gillies has demonstrated that learning together does affect learning outcomes (2016). Additionally, talking about an individual's experience levels the proverbial playing field where one can not know more or better than the other. This allows for a more open interaction (Vermeeren, 2025).

Alongside a lower literacy, citizens grow up detached from the natural world because they perceive nature to not exist in their environment. In a study among Dutch citizens only 60% percent of participants considered a park and only 38% considered their own garden to be part of nature (Klöne & Wattimury, 2022), which does not

invite citizens to support biodiversity in their environment. Garber encourages us to perceive the city as a habitat and goes as far as to say that we should consider these nonhumans in the construction of our urban environments (1987). Radical at the time, we now see that even prominent institutes like the World Economic Forum advocate for decentering humans in order to build more resilient city ecologies (2020).

"Cities offer food sources, places to live, wide open spaces, species to parasitize, species to prey upon, trees to nest in, buildings to roost on, warm evening skies to catch insects in, warm polluted waters to seek refuge in, rich effluents that support aquatic ecosystems, underground sewers to breed in, and cavernous subway tunnels and hundreds of thousands of miles of pipes to move about in."

Garber,
1987

The concept of Place also describes the importance of giving meaning to our learnings and to make environmental knowledge personally

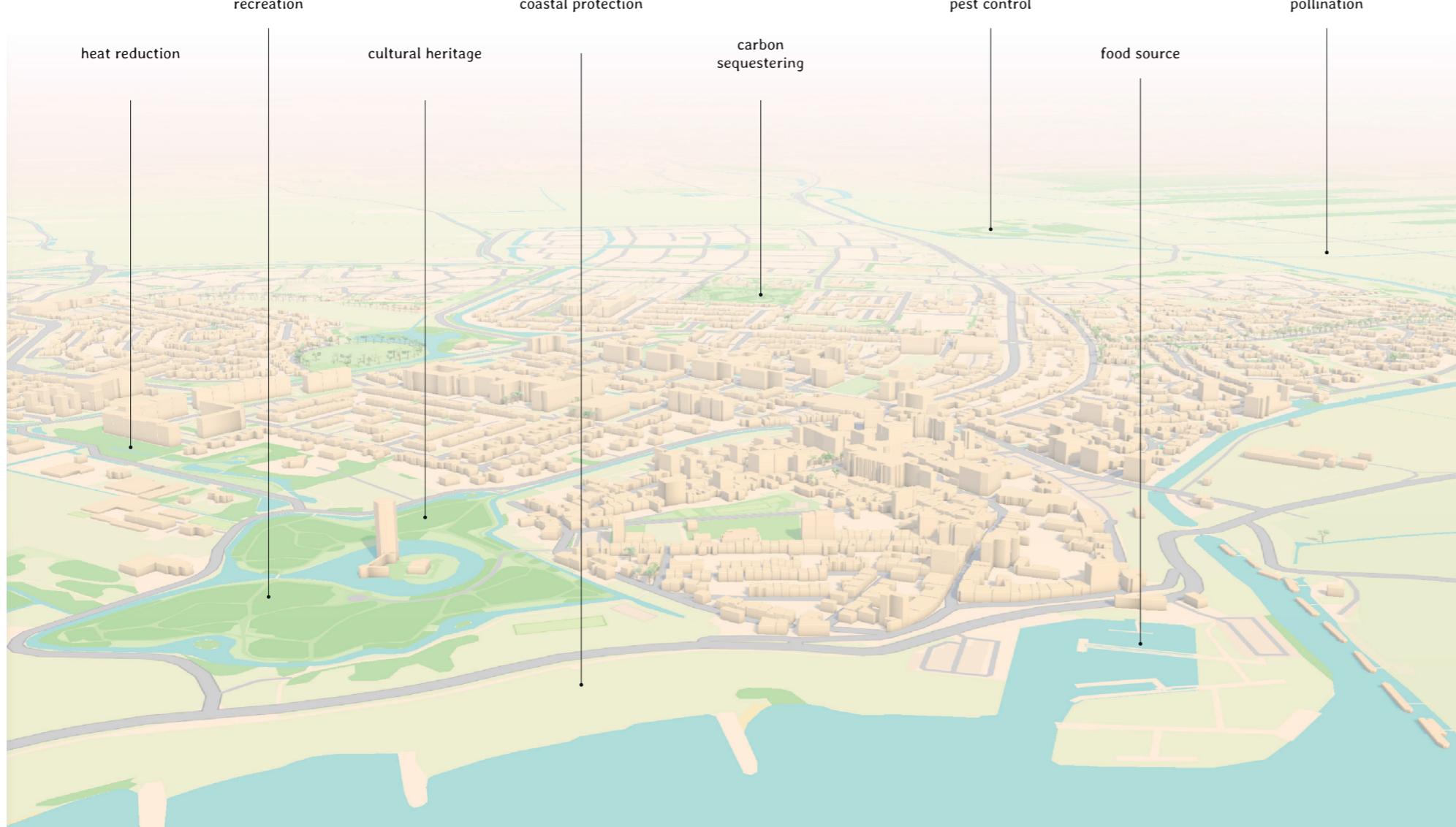
relevant (Singleton, 2015). Relating it to education, Sobel advocates for bringing learning to the local environment in order to prevent alienation from the knowledge students gain (1999). Here, it is used as a medium to give more meaning to the learnings, but this works bidirectional. Tying in with our more-than-human perspective, the act of learning about the local environment not only helps us in shifting from seeing our environment as decor, to seeing it as an actor in our life (Latour, 2004). It also aids us in developing meaningful connection with our environments (Bertolotti & De Luca, 2022). Through it, knowledge becomes both more meaningful as well as more desirable as it helps us to better understand the world around us.

Areas of impact

- Enabling citizens of the urban environment in the Netherlands to develop in their attitude
- Undermining the nature-culture dichotomy
- Connecting knowledge to the local environment
- Fostering love for a place as carrier for developing a sense of care for the environment at large
- Active participation in a place boosts a sense of responsibility
- Learning becomes personally relevant and purposeful by learning locally

Areas of impact

- Creating significant experiences that can be used as benchmark
- Enabling interaction with others on the topic



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Figure 13. a few examples of ecosystem services.

Heart

In addition to being able to reflect on one's experiences with the natural world, people need a relational understanding between them and the natural world. As one of the experts (biology education) consulted for this project says: "what you don't know, you can't love". This introduces the two important aspects of developing a thorough understanding of interrelation: knowledge and emotion.

The knowledge about biodiversity does not just mean the knowledge that biodiversity loss is a global problem. It is about developing a certain literacy in the language of biodiversity. Ecological literacy is a term that describes the degree to which an individual possesses ecological knowledge and understanding. Pitman et al. found that this is dependent on the way we value nature and the time we spend in nature (2017).

But as Nature philosopher Matthijs Schouten indicates with only knowledge about the biodiversity crisis you will not instill change:

"The ecological crisis is not just one of dying lifeforms, polluted rivers and global warming, it is a matter of the mind and soul" (Schouten, 2024)

Similarly, Wageningen University & Research says that for the societal change that is necessary to develop a biodiversity positive future we need three things: the knowledge of what biodiversity is, the skill to engage effectively and an emotional attachment (2022). Though we will discuss effective engagement in the Hand subchapter. We can say something about the knowledge about biodiversity and the emotional attachment.

The reports discussed in the introduction mainly cover the knowledge about biodiversity loss, but fail to provide readers with emotional attachment or skills to engage effectively. This emotional attachment or nature connectedness is founded on the value that the natural world has for that individual. There are three ways in which people can value the natural world: instrumental, relational and intrinsic (Wageningen University & Research, 2022; IPBES et al., 2022).

The degree to which individuals realise their dependency on the natural world plays a role in perceiving ecological knowledge as valuable. Global ecosystems offer so-called ecosystem services that provide direct monetary value for society as well as indirect value (Figure 13). Estimations are that over half of the global GDP is ecosystem services dependent (Swiss Re Ltd., 2020). On a governmental scale quantifying these ecosystem services allows us to make

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more informed decisions, but this creates an incomplete idea of what nature is worth (Plan Bureau voor de Leefomgeving & Wageningen University & Research, 2010). For the individual this is reflected not only in that this provides incomplete grounds to act on it also has the same effects as the reports, it does not speak to the soul. So while understanding the societal dependency of biodiversity is brought by knowledge about these instrumental services, it does not necessarily help in becoming a nature positive individual and it promotes the idea of humans as extractors of nature.

In addition to the instrumental value of nature, there is the relational value. Often overlooked because of the difficulty to monetise these aspects of nature, this form of valuing nature is about forming bonds between humans and place (IPBES et al., 2019). It includes what nature as a place can mean for an individual or a group. Here, cultural landscapes carry significance because they embody the nature culture dichotomy (e.g. Cornish Hedges); the idea that nature and culture exist separate from each other. Riley-Taylor argues that all social interactions exist in a biological system which influences and shapes these interactions (2002). It is in inspiration and wonder that we see this in action. Another component that Schinkel has shown to be of importance for education (2017). An example here is Heackel's *Kunstformen der Natur*, a book that describes the wonders of unseen diatoms as things to admire and marvel at (Figure 14). These illustrations, among others, have influenced humanity by inspiring the art nouveau movement. Acknowledging this (cultural) value, helps in perceiving humanity's place and participation in nature, rather than outside of it.

Finally, there is the intrinsic value of nature. Though not recognised by all humans, when we decenter humanity in nature we can acknowledge the agency and personhood of nonhumans. Moving beyond capitalist views on land use Tsing demonstrates that species cultivate each other creating a living landscape of human and nonhuman agency (2015). Kimmerer argues that being a person is not defined by being human, but by having agency and reciprocal relationships (2020). This is echoed by the documentary *My octopus teacher* as it follows a man that builds a relationship, across species boundaries, with an octopus (Reed & Ehrlich, 2020). It shows the inherent value a nonhuman can have as an individual, such as we may also bestow other people (Figure 15). It is therefore that Haraway invites us to build "kinship" with our nonhuman neighbours (2016). Acknowledging the intrinsic value of nonhumans encourages mutual understanding and respect. These factors may play in humbling humans and helping them understand that this world is shared with

Figure 14. illustrations by Ernst Haeckel to document the beauty of nature (1899)

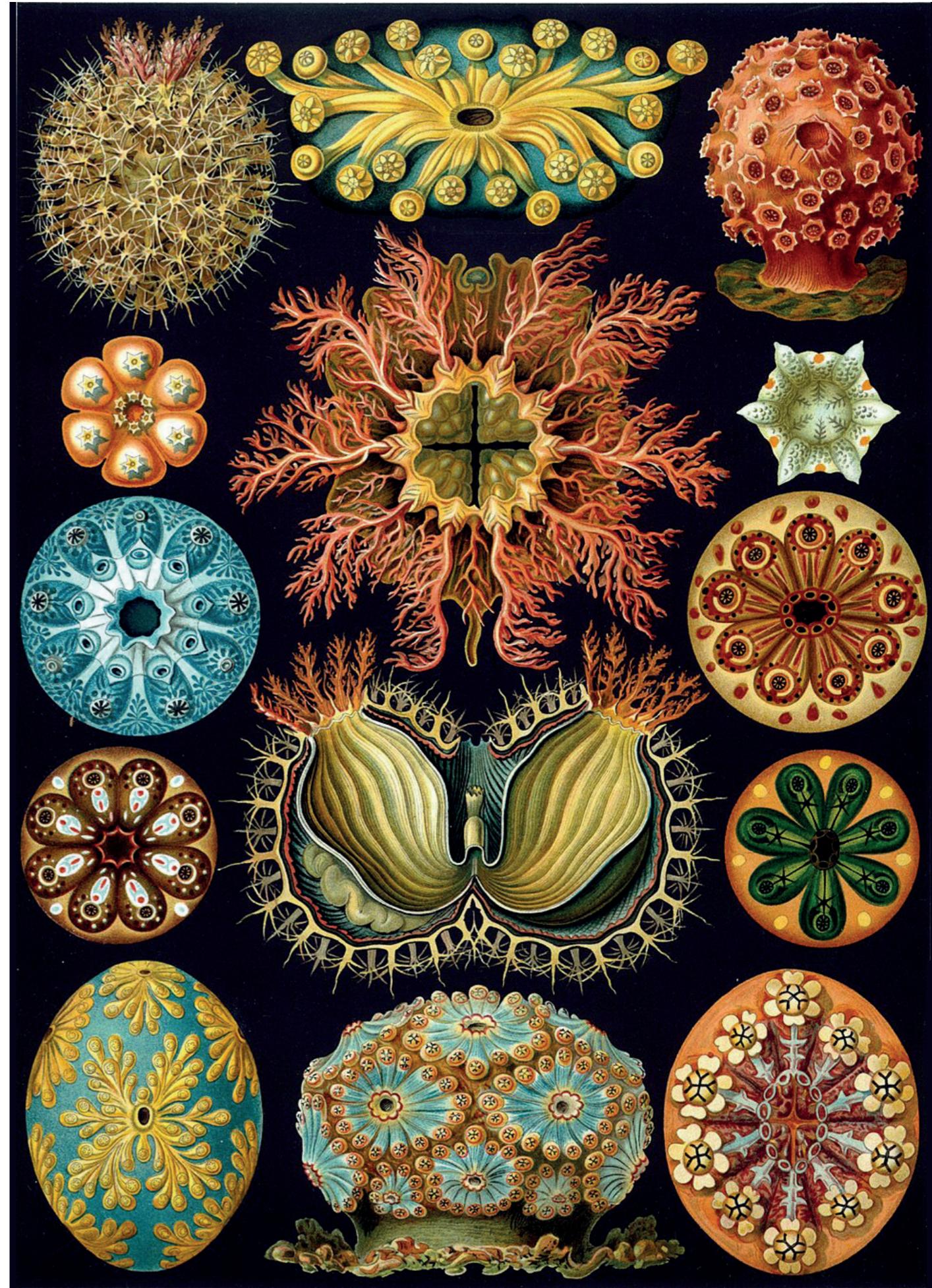




Figure 15.
frame from
my octopus
teacher (Reed &
Ehrlich, 2020)

other beings.

In addition to knowledge and understanding, nature connection is about the individual's perspective. In a study among Dutch citizens about one in three considered humanity to be the ruler of nature (Klöne & Wattimury, 2022). A relationship that denotes control and independence.

As the different values of nature suggest, this is a skewed view on our relation with the natural world as we are dependent on ecology, participate in nature and share with nonhumans. It is especially in the intrinsic value that we start to the influence of perspective. According to the IPBES institute four different perspectives towards our connection with nature can be adopted (2022). These perspectives are not mutually exclusive and are highly subjective and situational. Like the value system describes the kind of value one can attribute, the

perspectives presented by the IPBES institute describe a perspective that is informed by the viewers world-views, knowledge systems and guiding values (2022). Here it is not the goal to shift the target audience to a specific perspective, but rather to teach on the relevance of all four. All these perspectives have an important place in society and being aware of the different perspectives one can adopt allows for more informed decisions.

As becomes apparent by trying to divide ecological literacy and nature connection, these two appear to be in a bidirectional influence: if you are more ecologically literate you will probably develop more nature connections and vice versa. Having both ecological literacy and nature connection, people can develop a deeper understanding of their interrelation with nature. Here, Place returns as an important aspect as it can help to prevent alienation from the insights that ecologically literate and connected people may have. It is also in this final step of relating this perception to the self, that we find the transformational change.

Areas of impact

- Education in the human dependency on nature
- Promoting interconnection of all living beings
- Promoting individual connection with nature
- Making apparent the shared nature of our existence

Hand

Finally, to become, education needs to acknowledge the importance of effective engagement. The Hand in the transformational learning framework represents deep engagement. This refers to the manifestation of what is gained through involvement, participation and practice. As mentioned before, it is in the interaction with our environment that knowledge becomes meaningful to us.

Participation comes on a spectrum and this dictates the degree to which we can engage effectively (Cardullo & Kitchin, 2018). It is through this participation that citizens can develop responsibility for their local environment. In Figure 16 the model proposed by Cardullo and Kitchin about citizen responsibility and participation is cast and translated into effective engagement. It is this responsibility that brings about care for the environment or like an expert on education in rewilding said: "Only when you are involved, you can begin to care". So ideally we encourage effective engagement through participation. Currently only around 60% of Dutch citizens have been found to hold themselves accountable for the state of nature (Klöne & Wattimury, 2022). Where only half of the Dutch have both an intention to do something for the state of nature as well as the belief that they can do something meaningful. However, they don't know in what way. Therefore, creating opportunities for citizens to engage and develop a sense of ownership may strengthen the societal perspective on their influence on biodiversity loss.

Science in the making

It is not just skill that we can gain from this engagement, according to Latour this is also where science and facts are made (1987). As opposed to the structured and cleaned "**ready made science**". By allowing non-scientists to participate in the making of science a shared understanding of how facts are made can be found, this helps address the uncertainty in scientific discourse and invites dialogue (Verbeeck, 2021). In relation to biodiversity loss, this may address the absence of species from one year to the next in a specific area. A fact that may go unnoticed when its inhabitants are not involved. Allowing them to be part of the research and the dialogue can create momentum around events and situates the event in the real world for real people. Therefore, by being part of the generation of knowledge one can prevent alienation from the data.

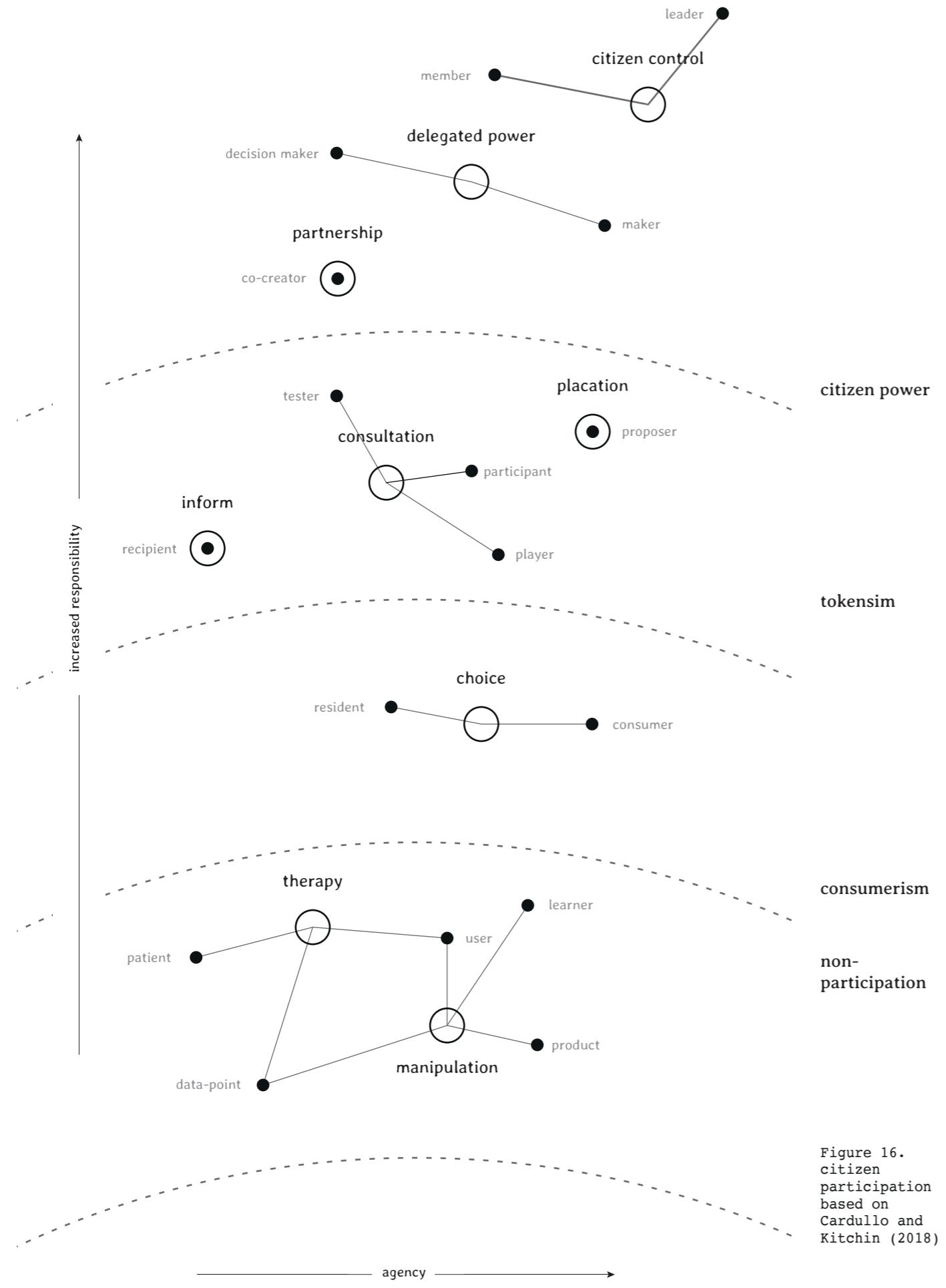


Figure 16.
citizen
participation
based on
Cardullo and
Kitchin (2018)

Participation as learning

Additionally, we can see action as a form of learning. It is through experimentation that individuals come to better understand the world in an embodied manner. Janssen demonstrates this by setting out to turn his balcony into a bee haven (2021). Through experimentation the author turns his desolate balcony into an oasis for bees in the center of Amsterdam. This experimentation shows the importance of testing our ideas and adapting our strategy to our findings. Therefore, creating actionable opportunities in the environment of people can help build the skills necessary for societal change.

Hybridisation in actions

“... And he [Latour] was precisely trying to explain that difference between the humans and the non-humans. With the discussion about bumper stickers. Guns kill people. The anti-gun activists had that bumper sticker. And then the National Rifle Association had, as a counter, People kill people. And the beautiful thing about Latour is that he shows, well, neither of them really. The English language shows this so well. That word *gunman*”

“... is a hybrid. People cannot, on their own, shoot someone dead. But a gun cannot either. Yet together, they can. So that gun can translate, transform, the intention of someone to express anger. Mediate, I would say in my own language. Into the intention to kill someone. And that shows something of a kind of activity of things. Which cannot be reduced to a kind of consciousness of things or anything like that.”

“... It is not animism that he wants. The only thing he wants to show is that if we want to understand social reality. That we will not get there with that purification of the subject and the objects. Because also socially, many views, ways of behaving, of us behaving. Are connected with the technologies, the objects we use...”

Verbeeck (2021)
[translated]

Areas of impact

- Allowing people to become part of the generation of knowledge helps them to internalise the implications.
- Through participation opportunities people can engage with the topic in an embodied way.
- By designing appropriate tools intention can be translated to action more effectively.

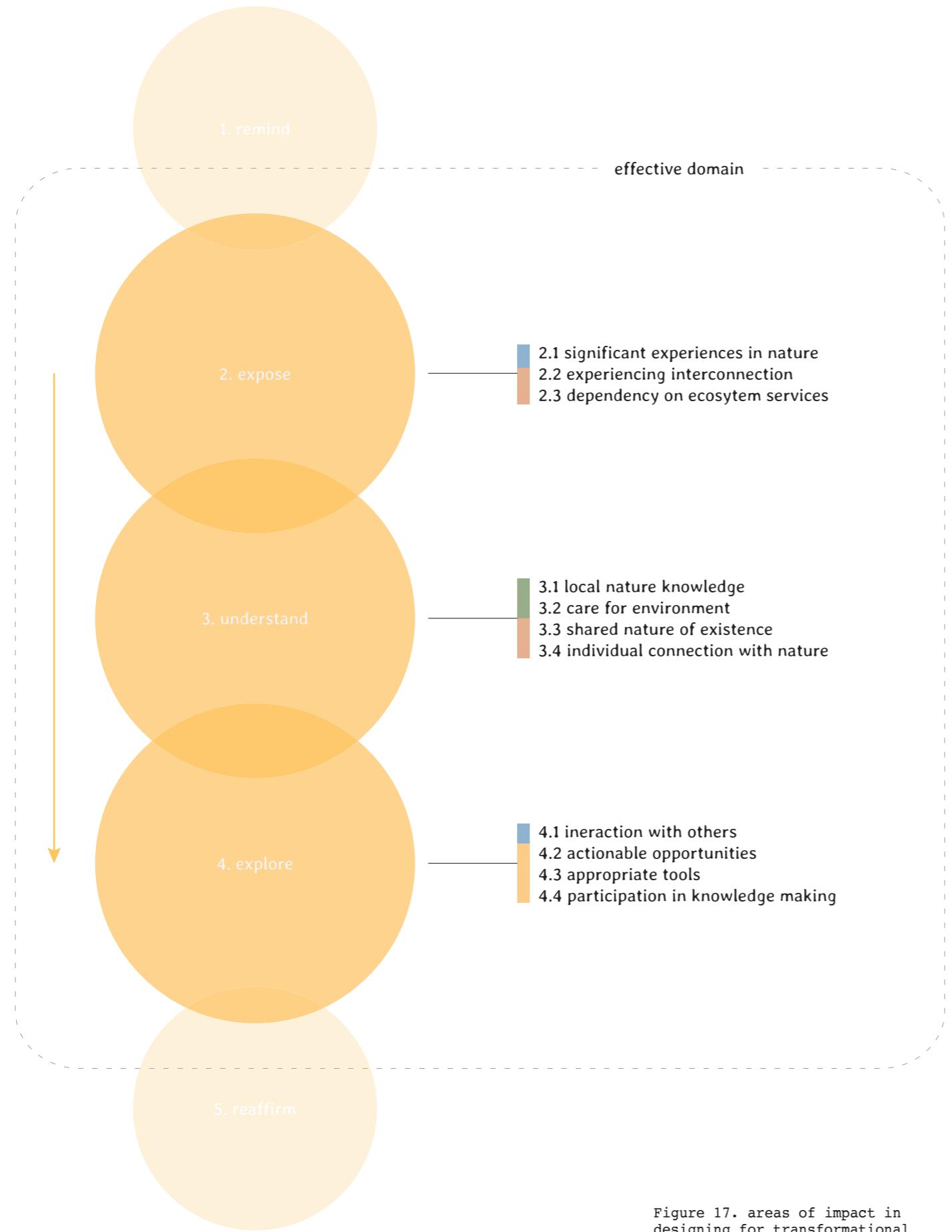


Figure 17. areas of impact in designing for transformational societal change in the context of Naturalis

Stakeholders

Based on the Head, Heart, Hand model different areas of impact have been identified. These areas of impact are not descriptive, but form potential pathways for stakeholders to engage with the topic of transformational learning experiences for the mitigation of biodiversity loss. This chapter discusses the two main stakeholders defined for this particular project.

Naturalis as an enabler

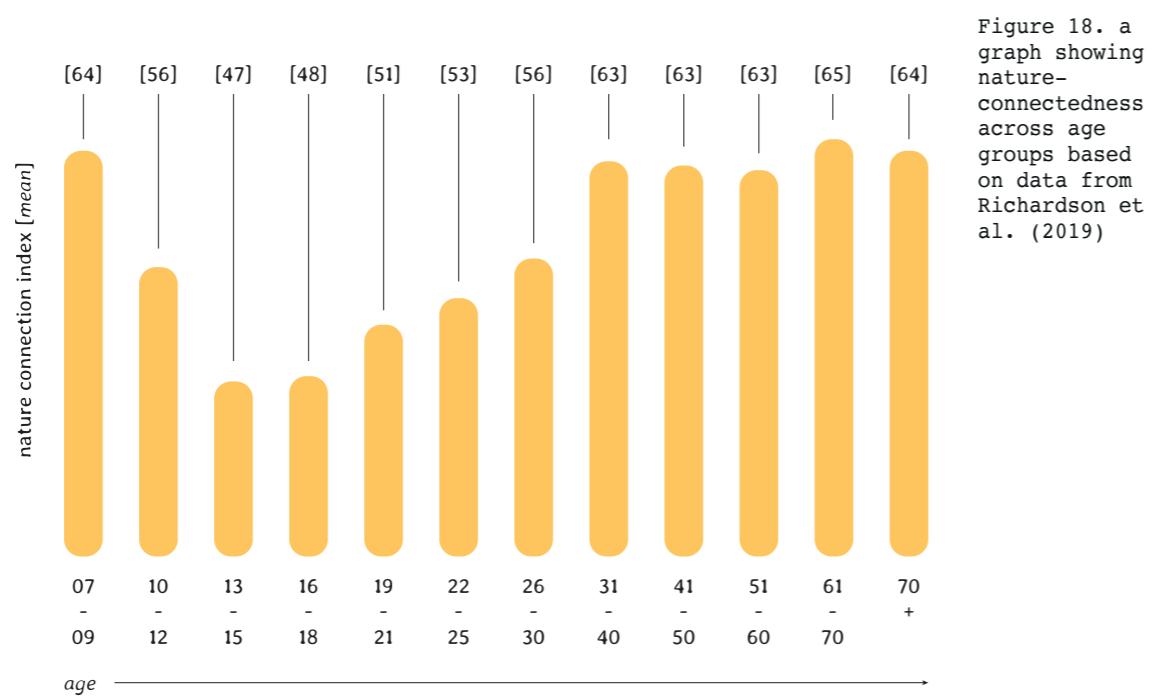
As main collaborator of the project and the formulator of the design brief we will first consider how these areas form opportunities for Naturalis. To converge on the collected areas of opportunity we can draw from a model proposed by Bergevin on the roles that museums can play in transformational societal change (2019). The model introduces five roles museums can have for a society. The role of Remind in this context means correcting misconceptions such as the nature-culture dichotomy. The role to Make Aware is about providing exposure for a certain issue to make it visible and credible specifically to sway visitor opinions. The role for Deeper Understanding refers to connecting to the visitors *umwelt* to prompt reflection and alternative ways of thinking. Inspire Action refers to the experimentation with alternative ways of being, it shows what impact visitors could make in adjusting their behaviour. Finally, Reaffirm is about validating new pathways after the behavioural transformation and communicating the effect of their contribution.

Figure 17 shows the five roles along with the relevant identified areas of impact and which part of the model they roughly correspond to. As one of the additional requirements of this project is the use outside of the museum

The umwelt of children

Assessing where Naturalis can make an impact and in what manner is also dependent on the target audience. For this project the target audience was set on urban children (ages 10-12). There are three things that make this group particularly well suited for this research: They will become decision makers, they are susceptible to the knowledge and they are the largest group that can make an impact.

In 2040 these children will be around the age that they enter adult life. It is in adulthood that we find more opportunities to exert agency on the environment around us. It is also in the preparation of students to become effective participants in a sustainable society, that (environmental) educators find a challenge (Capra, 2007). Van den Berg et al. found that more than half of Dutch children have little connection with nature and little skills in improving this (2023). Therefore, developing tools for the aid in becoming effective participants in a sustainable future seems to be a worthy investment for mitigating biodiversity loss.



Additionally, Wageningen University & Research suggests that the ideal age is between 8 and 12 to teach about biodiversity and to foster meaningful connection with nature (2022). We see that children younger than 10 have difficulty understanding the interconnected nature of ecology, making it difficult to provide a profound

understanding of the situation and a connection to the topic. Furthermore, children older than 12 tend to lose interest in the topic. Richardson et al. demonstrated that during high school children tend to lose the perception of being connected with nature (2019)(Figure 18). It is in this sweet spot that it serves to educate on ecological literacy and nature connection, so it can be “ready knowledge” by the time they start developing nature connection again. It is also at this age that children are keen on learning about the world and developing themselves on the topic. This is also echoed by the research done by van den Berg et al. as they identified that around one third of the children (ages 9-12) that identify as city child would like to be a nature child (2023). Based on these insights an argument can be made for taking children ages 10-12 as an interesting target audience.

In his book Brindle connects the more than human perspective with the notion of *umwelt*, someone's frame of reference (2022). Here too we need to consider the *umwelt* of our target audience, because as we have seen this situated perspective is part of the problem and with it part of the solution. Pitman et al. have demonstrated that the place you grow up, your perspective of and participation in your environmental matter when it comes to building ecological literacy and nature connection (2017). So when we talk about transformational change it serves to invest in the education of our children. The becoming of a sustainable society. Dutch children are more likely than ever to grow up in an urban environment and this number will only increase, van Hattum projected that by 2050 70% of people will live in cities (2022). We also know that urban elements reduce the nature connection experiences (Lengieza et al., 2025). Crowley established that children are also unlikely to frequently leave their neighbourhoods, cutting these children off from the necessary perceived exposure to the natural world (z.d.). Van den Berg et al. demonstrated that Dutch children tend to have little ecological literacy, marking 38% of Dutch children beginners (2023), which is likely connected to another insight that 50% of the participants rarely receive nature education. This indicates that those who grow up in urban environments are vulnerable to not being able to develop meaningful experiences with nature, suggesting that finding meaningful engagements with nature for this group could have an impact on the nature connection of the Netherlands.

Chapter conclusion

We end this chapter by returning to Roozenburg and Eekels and the way they describe a (design) problem (1995). This chapter has been dedicated to understanding the status quo and with it the current context of operation, the Dutch urban environment. Furthermore, we have seen that the continuation of business as usual is undesirable and we have started to grasp the underlying causes of these developments. In the next chapter we continue our exercise of filling in the problem definition.

RQ2.A

Why should we invest in developing a biodiversity positive attitude?

Species extinction rates are accelerating, and human behaviour can significantly influence this trend. A positive attitude towards biodiversity not only helps us create healthier and more livable environments but also fosters a deeper connection with the natural world. By appreciating and valuing our surroundings, we can find more meaning in our surroundings and a sense of worth outside of monetary systems.

RQ2.B

What are the fundamental forces and principles that prohibit a biodiversity positive society right now in the Netherlands?

Currently, several barriers hinder the development of a biodiversity-positive society. Especially citizens, and particularly young people, lack meaningful interactions with nature and often perceive themselves as separate from it. Limited knowledge and perspectives for action further reduce people's ability to contribute positively to biodiversity. Additionally, there is a shortage of accessible tools and resources to support biodiversity-positive behavior.



Figure 19. The illustrations of Maria Sibylla Merian demonstrate all of the unique ways species use, depend on and feed on each other.

Niches

Imagining alternative ways of being

Defining approach
Futuring
Keystone citizen
Problem statement
Design goals
Chapter conclusion

In the previous chapter, we established the current state of the societal attitude towards biodiversity and the societal forces that influence this. To complete the problem definition, this chapter looks ahead and questions how we can change this situation. This is done by triangulating research insights from workshops, consultations and literature. Based on these the keystone citizen design framework is formulated, an idealised version of what user we should strive to design for and what education should aim for as a tool for becoming. This framework highlights the multiplicity of opportunities in designing for desired futures. In line with our ecology analogy, we can say that these different pathways symbolise ecological niches institutes such as Naturalis can explore. We conclude the chapter with a series of design goals, which will function as the starting point for the ideation process highlighted in the next chapter.

RQ3.A: *What does a biodiversity positive future look like?*

RQ3.B: *How can we design for the development of a biodiversity positive attitude in 10-12 year olds?*

Figure 20. an overview of design activities and related domains

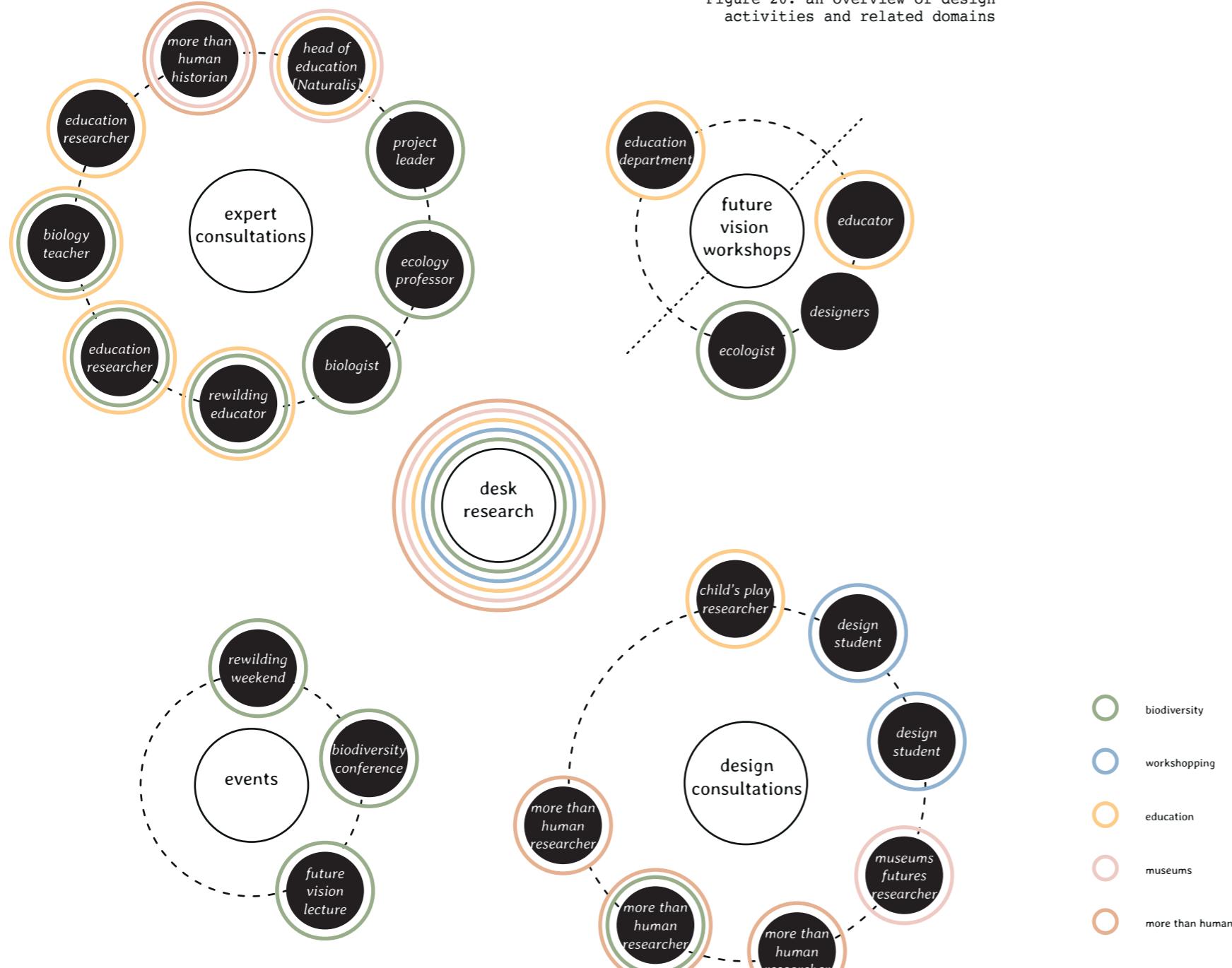
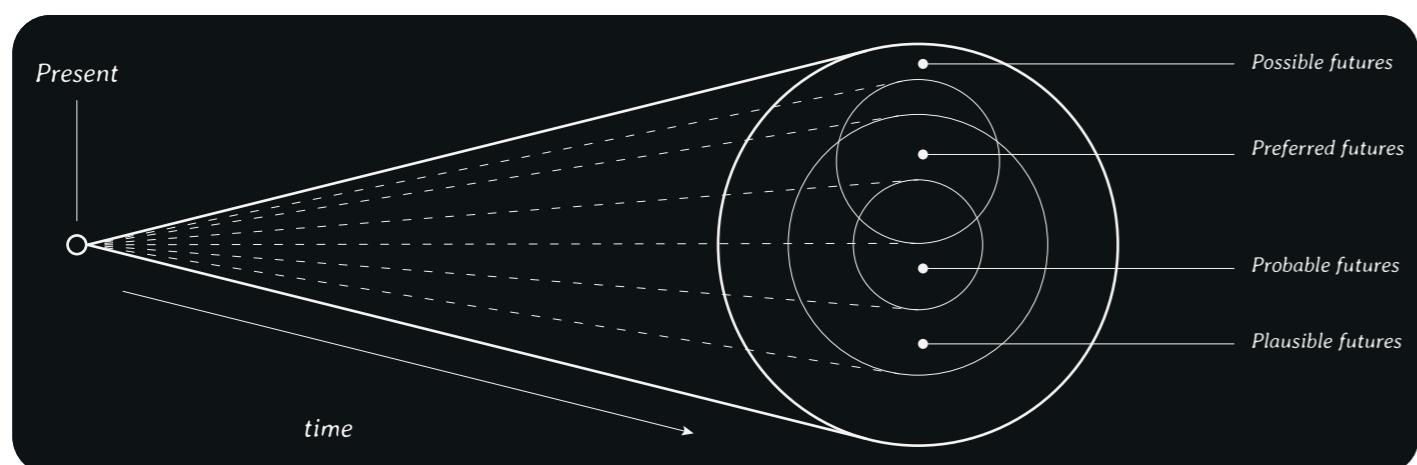


Figure 21. a schematic view of different futures based on Mitrović et al. (2021)



defining approach

In the last chapter we looked at the past and the present components of the problem definition. In this chapter we use different methods to investigate the forward looking elements. The future visioning method proposed by van der Helm is used to gain insight into the desired situation (2008). Here it serves to point out that a future vision can be many things (Figure 21). For this thesis van der Helm's model was used which positions a future vision as a strategic tool to inform design decisions and a method of communicating desired results to stakeholders.

These preferred futures serve as a tool to direct (societal) change. By adopting this perspective this method does not only inform the problem definition, but also becomes a means to evaluate emerging ideas and concepts along the way. Though there are multiple ways to go about this, for this thesis these five guidelines are used to formulate the future vision:

- It describes an ideal, though informed by contextual conditions
- It functions as a guide
- It is anchored in a driving idea
- It addresses the underlying forces
- It has map like qualities, helping stakeholders to navigate potential directions

To come to this vision and the following framework, constraints and delimitation an array of design activities were conducted across domains to further define the problem definition (Figure 20).

To make the problem definition, problem statement and framework actionable the chapter concludes with a design goal tree. This is an appropriation from the **design goal**: a statement dictating what will be achieved with a design. Here the format proposed by Hekkert and van Dijk is used to create a tree of opportunities to explore in relation to the overarching research question: How can we design digital artefacts to encourage a biodiversity positive attitude? (2016). This not only provides a great starting point for ideation in the next chapter, but also functions as a framework to assess ideas and concepts.

Futuring

In order to craft a solid vision containing the guidelines presented above, snippets of developments, ideals and principles have been collected by triangulating knowledge. Here, the insights from the literature review have been cross-referenced with the input from expert consultations, future vision workshops and three events addressing the future of biodiversity. Notably there are little conflicting insights indicating the possibility of a tight match between the disciplines of situated learning, more than human design and regenerative ecological practices. Two frictions that do arise worth mentioning are the indirect disagreement of the reach of institutes and the role of humans as participants in the regeneration of biodiversity, which we will return to after having discussed the insights from the different research activities. Alongside thes gathering of information, different future visions from the rewilding scene were sampled to see what makes a good vision (eg. Linnartz et al., 2023; Meesters et al., 2024; Helmer, 2024).

Expert consultations

As the project is connected to the education department of Naturalis eight experts connected to the domains of ecology, plot development, education and museums were consulted alongside five members of the education department. The insights from these experts have been synthesised, along with the insights from the workshops and events, into three narratives. These narratives describe the insights specific to three domains in an ideal situation.



Figure 22.
workshop
impression

Future visioning workshops

To dive deeper into the way stakeholders foresee the future, I hosted two future vision workshops, one with the educational department and another with stakeholders from ecology, museums and education. Most of these insights are translated into the three narratives, however the sessions also informed the role of the actual design in the lives of people and informed which frameworks form a solid base for starting the design process.

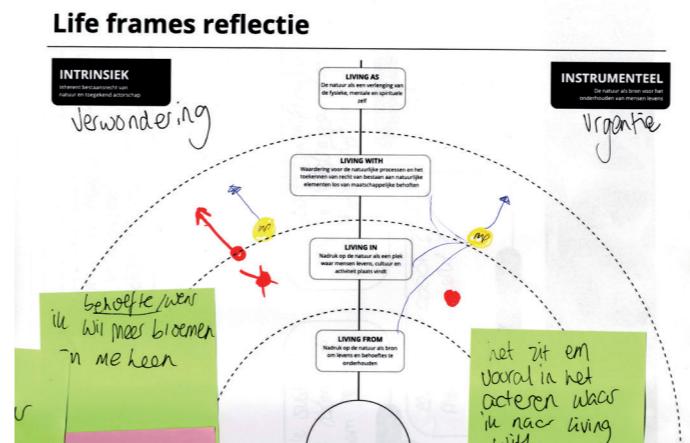


Figure 23.
positioning of
current and
desired life
frame from a
participants

A crucial insight is that the life frames framework (IPBES et al., 2022) does not form a good basis for the starting point of a design process. As the framework introduces different world views it is easy to think that working towards a particular worldview as design outcome is desirable, however the sessions proved that these world views are highly situational and also subjective. It was difficult to find consensus on what is right and what is wrong, shifting the debate from the question how to improve biodiversity to a moral one.

Furthermore, the workshop provided insight into the necessity to think of the lifespan of the activity provided by the design. One of the participants mentioned a fond memory of creating a herbarium, however they felt rather let down because the herbarium had no meaning for them after the creation. There was no purpose to keeping it around. Finding activities that provide meaning beyond the activity itself may help in the continuation of the message that the activity carries.

Events

Additionally, I took part in three events that addressed the future of biodiversity in order to sample ideas from keynote speakers and visitors and to further ground the insights from the other research activities. Here I informally chatted with visitors to subject my interpretation of the collected insight to new ideas and to test for inconsistencies. Together with the other research activities this provided three narratives, written from an ideal standpoint.



Figure 24. an example of a suitable vegetation group for Leiden

Nature

"The natural world should not be pushed to the margins of society. It weaves through the streets, walls and gardens in the form of native plants reclaiming paved areas and insects returning to biodiversity poor areas. Fallow corners are filled with a unique **vegetation** and considered an enrichment of the street as it brings life and colour to the environment. Municipalities don't manage this nature, it's the citizens that care for it and help it flourish. Balconies, courtyards and facade gardens bloom with native species creating a buzz and well needed corridors between the larger parks and canals of the city. Nature is not curated or confined, it is given space to sprawl and just be to make room for the natural processes of pollination, regeneration and decay."

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Education

"Education on biodiversity and ecology starts with wonder, muddy hands and a beetle on a leaf. It embraces the world of its student, both literally as well as figuratively. The things they learn are grounded in their environment and bring meaning to their world. Theory is brought into practice by field excursions and hours in the garden. It helps them in making the place that they live in meaningful. Here, nature is not just something to learn about, but it is synonymous to their relationship with the world. Through education they are not studying nonhumans, they are getting to know them, they start to form a connection. There is space for what the students feel, where global issues become complex but they learn how this uncertainty breathes potential and possibility. Belonging to the world we learn that regeneration benefits all organisms and that acting on behalf of it is not only a path to knowledge but also a way to be part of it."

Museums

"Museums exist by virtue of society and therefore give back to it. They play a role in telling the stories society needs. Within the museum visitors explore narratives and alternate ways of being through experimentation and reflection, driven by the narrative that nature and culture are intertwined. The narrative is continued beyond the museum walls. They reach out to set up platforms, be part of the journey of becoming and collaborate with others to create meaning. Connected partners, institutes and schools reach out to share knowledge and to continue the journey of wonder found inside the museum, connecting the experience not only to the physical environment of visitors but also their world of experience."

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Society

"People are curious, they care. Society is built on involvement and participation. Municipalities enable initiatives to rise up left and right led by their proactive citizens. A willingness to contribute and to find common ground with each other and non human neighbours permeates the spirit of society. Biodiversity is part of society, the species around them are their neighbours, not just entities they know the name of. They recognise their rhythms, their roles and their worth for the environment. Citizens also recognise their own worth in this web of beings. Change is met with patience and generosity. Knowledge is shared and exchanged. Regeneration is not a government affair, it is a collective effort."

Reach of educational institutes

An additional tension arises in the reach or competency belief of institutes. On the one hand institutes aim for creating transformational experiences, while on the other hand most experts agree that certain experiences can not be substituted, like the exposure to nature. It is then the smart connection between (learning) environments that enables best of both worlds, however these have been proven difficult to set up. However as the saying goes I believe that aiming for the moon will still leave you among the stars or in other words making these experiences an ambition will ultimately contribute to the larger picture even though they may have not been as successful.

Core insights

- Developing a biodiversity positive attitude is not necessarily about changing your perspective, but mainly about deepening understanding of relevance, connection and worth.
- In discussing desired futures with stakeholders, talking about outcomes is easier than talking about ethics.
- To build an attitude the activities that contribute to a certain attitude need to stay relevant even after completion of the activity
- Naturalis can not force a transformative experience, but by acknowledging its strengths and weaknesses is able to provide a setting that may promote it.
- Enabling people to act keeps them engaged with the topic even though this might not always be the best solution.

Role of humans as participants

Although the consulted experts agree that humans are a part of the natural world and should embrace their participation in nature, there seems to be a tension in the amount of agency we bestow on ourselves. As humans we should be wary of both thinking we control or dominate nature into doing our will or perceiving ourselves having no agency in the alteration of our environment for the improvement of biodiversity. As several experts pointed out, the natural systems human activity has affected will regenerate by themselves; only humans tend to get impatient with the process. Making this a human problem and not necessarily one for nature. And by framing it as a problem it already denotes that humans need to solve it furthering the ideas of humans being the controlling force of nature. What this means for this project is that I acknowledge that it is not ideal to have humans want to act on behalf of nature in all situations, but that the harm done by preventing individuals from acting is greater in the long term. So the facilitation of frames for action is, like one of the interviewees mentioned, a functional compromise rather than an undesirable ideal scenario.

Naturalis and other institutes provide a platform to learn and grow

even in highly populated areas greenery is around the corner

foodforests border the city

a vegetation that is unique to the city can be found in every park

green and blue veins run uninterrupted through the city



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A biodiversity positive future

Compending the insights from these activities reveals what a biodiversity positive future might look like on two levels: city ecologies and citizen attitude.

Future city ecologies

In imagining a future city ecology we can make a distinction between the architecture of society and the applications that enable or support the architectural shift. Where the former provides us with a new societal perspective like the narratives we saw before, the latter provides us with tangible implementations.

vision

"In 2040 we have captivated the passion of children by creating a learning ecosystem that operates on the intersection of the factual learning of schools, the inspiration for action found in the museum and the need for actionability outside of these environments to plant a seed for holding your surroundings and more-than-human neighbours dear to be able to act on this intrinsic motivation by the time that these children become acting members of societies, neighbourhoods and households."

Figure 25. city ecology vision

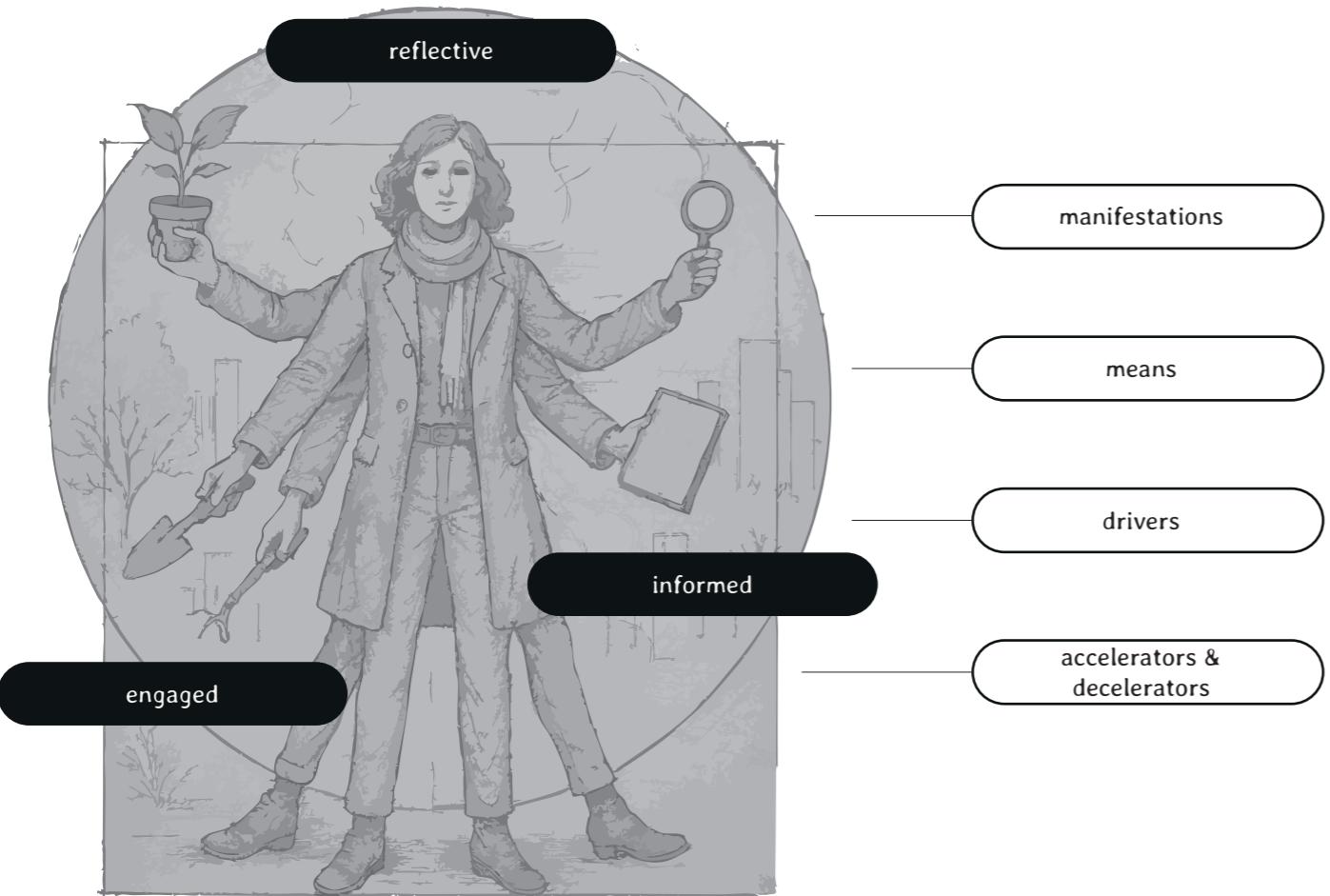


Figure 26.
interplay of
factors that
influence the
biodiversity
positive
attitude

A more-than-human perspective of citizenship

The idea behind the keystone citizen is not only that they create a biodiverse world. It is also the internalisation of the more than human philosophy of interrelatedness and subjectivity that is embraced in this way of being. In ecological terms a **keystone species** is a species that affects its ecosystem disproportionately to their biomass (Worm & Paine, 2016). What this translates to is that these species tend to have a lot of other species depend on them for fulfilling their ecological role. Here, I would like to draw a parallel between beavers and citizens. Beavers create dams that have been known to flood large areas of forests creating a unique environment that supports different wildlife. Similarly, Garber already showed us that the creation of the urban environment has created a unique habitat (1987). But he goes beyond the idea that humans just create the habitat, they participate in it.

"We city inhabitants are animals who affect our surroundings in a natural manner, like any other creature."

Garber,
1987

Furthermore, Worm & Paine also acknowledge that humans have been treated as externalities in the analysis of ecosystems, but should be considered while modelling them (2016). This ties well with the more than human idea that nature is not decor but an actor in our lives, or rather we are an actor in nature with numerous more than human actors around us that we affect and that affect us (Latour, 1987).

The keystone citizen

Although the future vision of the city ecology aids in driving the conversation about what we want to achieve as society, it is not helpful as is from an educator's perspective. Here we are more interested in what people need to become to enable such a future and how educational products may facilitate that becoming. Therefore, to accompany the ideal city ecology we can imagine an ideal citizen. An individual that possesses the knowledge, skill and intention to make the biodiversity positive future possible. An individual that possesses the epitome of the biodiversity positive attitude. Through the consultations with experts in the fields of ecology, design and education, and the conversations had with experts through experience in biodiversity positive behaviour, I have come to realise that the development of such an attitude is the interaction between several factors (Figure 26). In this interaction we have accelerators and decelerators that influence the speed at which an individual may develop themselves, but ultimately the keystone citizen is about manifesting aspects of the attitude through different means, driven by personal motivators.

Side note:

The choice for the term keystone species rather than ecosystem engineers, has been a deliberate one. Although they are closely related, I believe that the ecosystem engineer carries a notion of dominance and control, while the connotation of keystone species leaves open the possibility of chance and randomness. therefore I believe this term to be closer to the ideals of the more than human discipline.

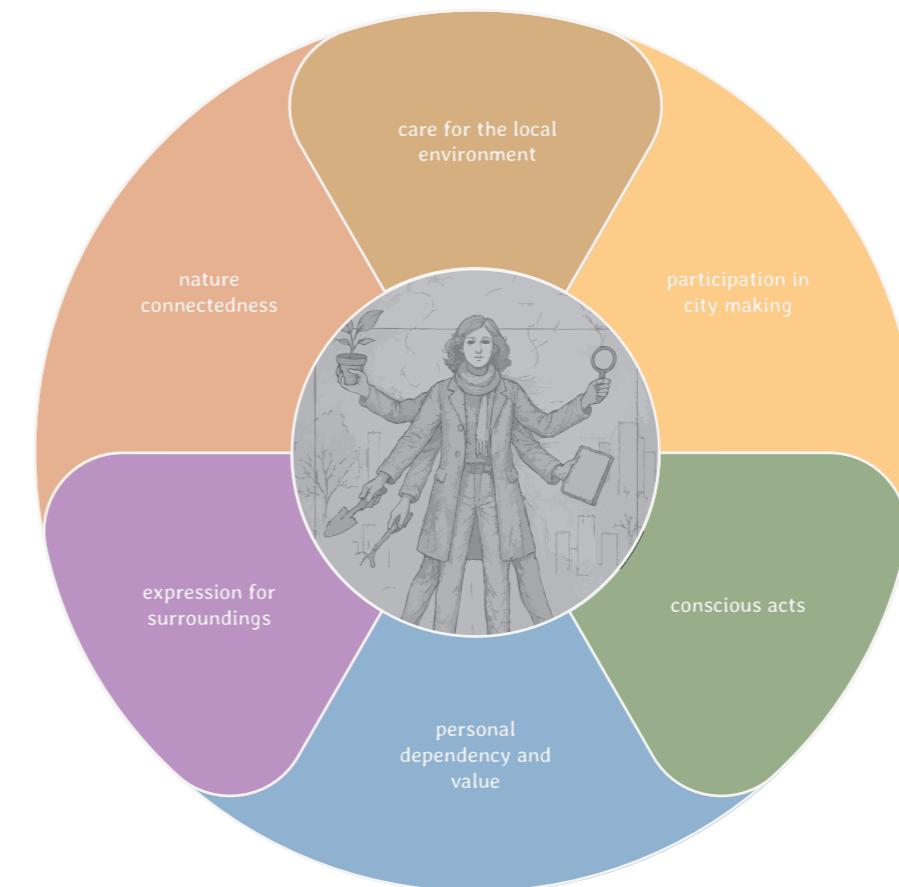
Designing for a biodiversity positive attitude

Based on the keystone citizen we can define our idea of a biodiversity positive attitude. To determine this we return to the Head Heart, Hand model (Singleton, 2015) where we can consider an individual who is developed in all three domains to have a biodiversity positive attitude. Although adopting an attitude is not entirely voluntary, one can develop an attitude over time through their previous experiences, the knowledge they have gained and the emotions they have felt. The more one adopts a certain attitude the more proficient one becomes in applying it. The attitude is therefore the manner in which we interact with the world. The person's behaviour on the other hand is the way in which this is manifested and which is informed by the qualities that one embodies. Ideally we want behaviour that reflects the notion of the person being a keystone species like mentioned above. But to get there we need to develop an attitude that allows for such behaviour. Through the research activities several factors have been found that have an effect on the development and carrying out of a biodiversity positive attitude. Particularly, the area that a certain activity contributes to (manifestation), the force that drives people to engage with certain activities (driver), the nature of the activity itself that is being engaged (means) and the forces that play a role in the continuation of the development of individuals (accelerators & decelerators).

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Manifestations

Looking at the Head, Heart, Hand model the biodiversity positive attitude can manifest itself in three domains, overlapping these domains provides us with six areas that show how elements of the biodiversity positive attitude can manifest (Figure 27). These six areas describe both what part of the attitude is developed as well as in what manner it is carried out. Note that the Place is left out as this is dictated by the way we apply the framework later.



1. Nature connectedness: the emotional attachment to the natural world.
2. Care for the local environment: the love one holds and acts on for their environment
3. Participation in city making: the activities one conducts to bring meaning to their environment
4. Conscious acts: the change in habits one does based on the knowledge of their impact
5. Personal dependency and value: the degree to which an individual understands and acknowledges their place in nature
6. Expression for their surroundings: the vocation of ideals and choices in favour of the world

Figure 27. the different manifestations of a biodiversity positive attitude

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Drivers

Working back from what we would like to manifest we need to consider how people become engaged. In this thesis we use the word driver to indicate what feeds or motivates the actions of an individual. Ideally different drivers are engaged throughout the education of an individual to instigate a snowball effect. Based on the interviews with experts and the future vision workshops 54 drivers were identified which can be clustered into four categories (Figure 28): As we are looking for the intrinsic development of a biodiversity positive attitude, I have omitted the incentive drivers from the design considerations. Apart from understanding what motivates people to develop their biodiversity positive attitude. These drivers also help to formulate desired interactions for designing appropriate tools for the development of a biodiversity positive attitude.

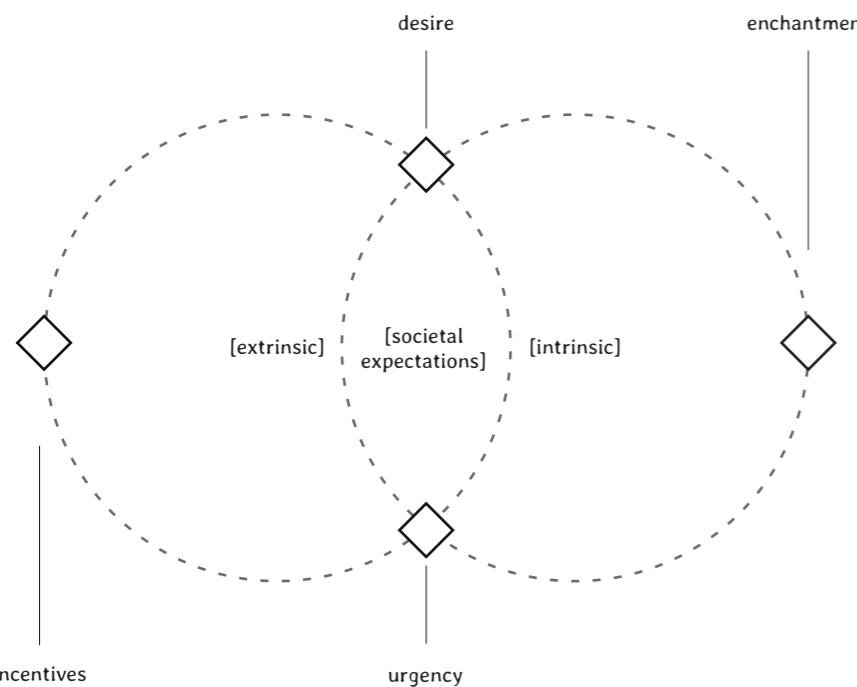


Figure 28.
categories of drivers for
developing a biodiversity positive
attitude

1. Incentives: includes laws, policy and subsidies
2. Desire: Best described by Deleuze & Guitari as a positive and generative force (1972)
3. Enchantment: Described by Bennett as a state of magical delight that opens up the marvels of life (2001)
4. Urgency: As a driver, we can turn to Kierkegaard, who defines it as a need for immediate existential action especially in moral or spiritual crises (1844).

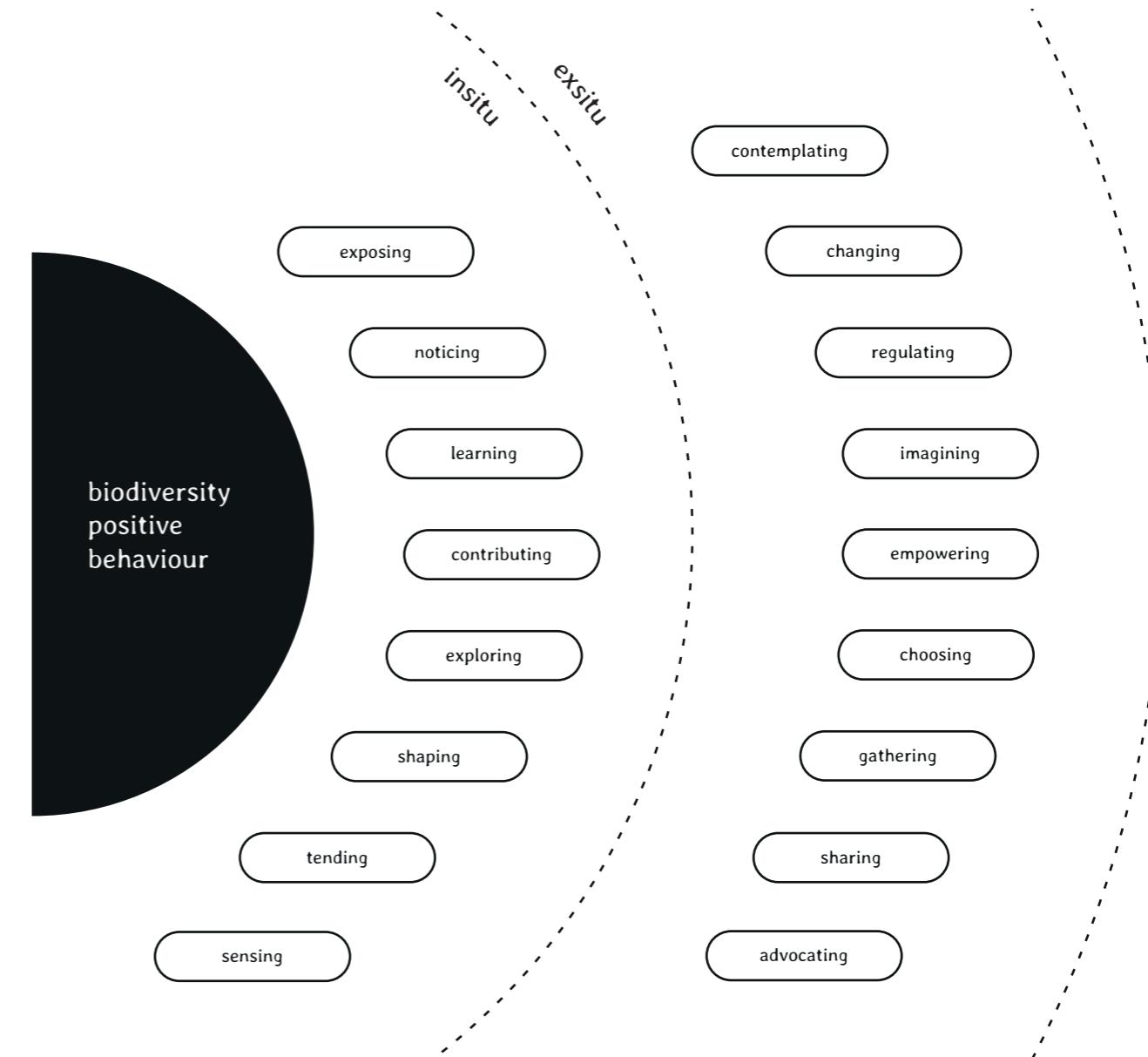


Figure 29. an overview of the different categories of means both in situ and ex situ

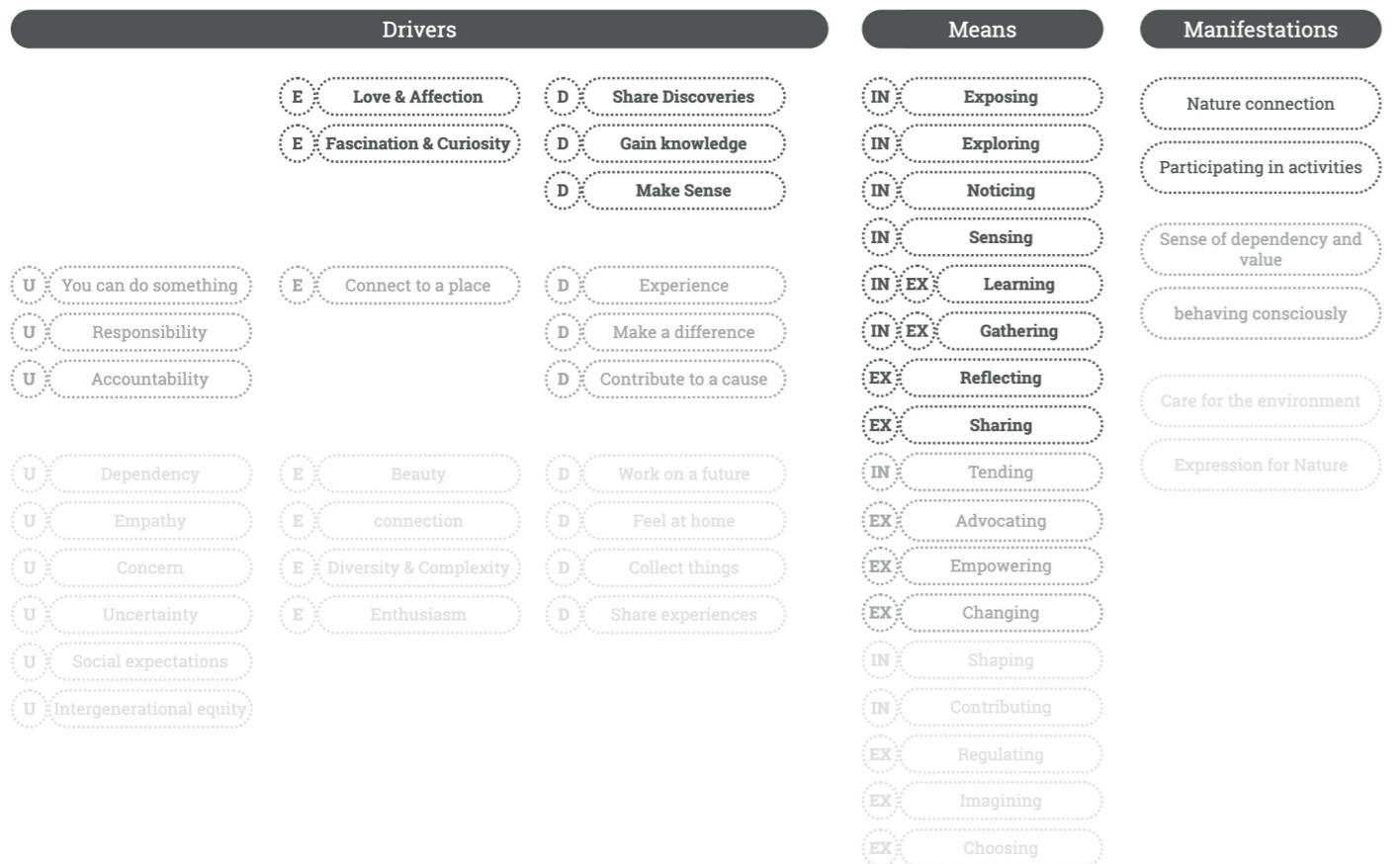
Means

Alongside the manifestation and the driving force, there is also the means. The means describe in what way the biodiversity positive attitude is carried out and by doing so developed. Therefore, the means all translate to activity verbs. Here we can make a distinction between the means that are carried out in situ, in the environment it concerns, and ex situ, those that have indirect impact on the environment it concerns. Through the research activities 89 activities have been found that support the development of a biodiversity positive attitude. These have been clustered into 18 overarching activities (Figure 29).

Delimitation

Accelerators & decelerators

Finally, several factors were identified that accelerated or decelerated the becoming of a keystone citizen. In the identified factors there is a distinction to be made between. The factors that describe the character of an individual are important to consider, but since this educational product that emerges from the research is not necessarily used by people with these characteristics, they have been omitted from the design requirements. The other factors describe the state of a person or an interaction with the world / product. Therefore, these can be carried over to the constraints drafted later in this chapter.



A good problem definition also delimits and scopes the project. In a session with members from the education department we assessed which manifestations, means and drivers are appropriate for the educational team of Naturalis to tackle in an educational product that is used outside of the museum. In this session we considered the strategic goals of Naturalis and the strengths of the education department. Together with the collected research insights five domains emerge that scope the project further (Figure 30).

In this session we first considered whether the collected drivers are best appealed to in the context we created or a different one (e.g. inside the museum). Something that we considered here is the imaginative effect of museums. This effect allows people to explore alternate ways of being without any real world drawbacks. Although an important factor in the transformative experience museums can offer, this is harder to realise outside of the museum building (Bergevin, 2019). This is also confirmed by one of the expert consultations with an art historian who specialises in more than human narratives. They elaborated that people enter a museum with the knowledge that they might be subjected to such exploration, it was a conscious choice to go there physically and mentally. Putting it in the public space, breaks the illusion of near limitless possibilities.

Notably, the drivers connected to urgency were found to be less important than enchantment and desire drivers. Looking at the research this makes sense in the connotation of these drivers. Generally they denote a negative or oppressive experience, while we have seen that effective narratives are those that balance the negative and positive as well as leave room for the children to develop their own thoughts.

Furthermore, the means and manifestations were assessed on how well they match with the strategic goals of Naturalis and the competences of the education department (Naturalis, 2024). Here we assessed which means and manifestations are best supported by Naturalis and which are better supported by other institutes in addition to looking at the product portfolio of Naturalis and how these activities can complement it.

Figure 30.
delimitation
of the
manifestations,
means and
drivers

Constraints

As a final step before filling in the problem definition we need to consider the constraints that working within this context brings with it. Four perspectives emerge when reviewing the collected insights: more-than-human, keystone citizen, Naturalis, children. Apart from driving the convergence of ideas, these constraints are also used to validate the eventual product concept in user tests alongside the key words of the design statement. On the next spread an overview of the different constraints can be found (Figure 3).

More-than-human perspective

These constraints emerge from the more-than-human perspective adopted for this project. Maintaining these constraints guarantees, to some degree, more-than-human representation in the project. Since these consider the interaction between humans and the more than human world, these constraints can be evaluated in user tests through targeted questions.

Keystone citizens perspective

Connected to the more than human perspective we can also draft constraints related to the becoming of a keystone citizen. These are connected to the kind of education experience the product provides and what the user takes out of them. These are best reviewed by an expert in the field of education to make an educated guess whether or not the product will facilitate these.

Naturalis perspective

Apart from the desire to provide perspectives for action to their audience, there are several other constraints that have come up throughout the process. These can be used to determine how easy it will be to build momentum within Naturalis to adapt the product concept.

Children (ages 10-12) perspective

Finally, we also need to consider the user, because if our designs are too complex or not engaging enough most of the benefits will be lost. The constraints that follow from this perspective form the groundwork for user testing the eventual product.

More-than-human perspective

- 1.1 The design promotes the idea that nature is an actor in its own right.
- 1.2 The design promotes getting to know nonhumans beyond their names.
- 1.3 The design promotes systemic insight into the complexity of nature
- 1.4 The design prevents users from overlooking nature.
- 1.5 The design does not promote an extractionist mindset.

Keystone citizens perspective

- 2.1 The design promotes the development of a biodiversity positive attitude.
- 2.2 The design relates knowledge to the local environment of its user.
- 2.3 The design plays into the strengths of different learning environments.
- 2.4 The design promotes a proactive attitude towards the environment.

Naturalis perspective

- 3.1 The design is uniquely tied to Naturalis.
- 3.2 The design provides perspectives for action.
- 3.3 The design can be connected to at least 2 of the 6 pack.
- 3.4 The design connects people to the museum.
- 3.5 The design has a digital component.
- 3.6 The design is connected to the larger digital ecosystem of Naturalis.
- 3.7 The design needs to be appropriate for different (urban) environments.

Children (ages 10-12) perspective

- 4.1 The design builds up step by step.
- 4.2 The design conveys a neutral message (not positive not negative).
- 4.3 The design acknowledges the agency children have.
- 4.4 The design combines physical activity with cognitive activity.
- 4.5 The design is engaging to use.

Problem definition

According to Roozenburg and Eekels we now have addressed all the building blocks necessary to formulate a thorough problem definition (1995). In this summary run through the different elements to reframe the initial request posed by Naturalis. This problem statement not only informs the start of the design process, it also functions as a benchmark we can use to evaluate design outcomes.

context The context we are operating in is the Dutch urban environment. This environment is created and filled in with a western perspective on nature. Generally this means that inhabitants have overlooked the importance of biodiversity and that the society generally carries the idea that nature is not around us and that we are not a part of it to a large extent. In the following chapter we will dive more into how the environment plays a role in the final concept.

stakeholders The first stakeholder is our target audience: children aged 10-12. They are usually in grade 7 or 8 of primary school. These children often have considerable free time but are limited in how they can spend it (e.g., Pokémon Go requires adult supervision for those under 12). While this may be a generalization, the second stakeholder is arguably the natural world, which stands to gain significantly from individuals who value high and healthy biodiversity. Additionally, we have Naturalis who aims to provide perspectives for action and finally our future generations have a stake in developing adults who make choices that will benefit them now and in the years to come.

undesirable situation Biodiversity loss is happening at an alarming rate, this is not only bad for economics through the disruption of ecosystem services, it is also a loss for the integrity of the system as a whole and the intrinsic worth of nonhuman organisms. Although there is information available on ways to mitigate this, little actually happens. Continuing on this trajectory means an immense loss of species diversity.

underlying causes On higher levels, governments have not made it their priority to address these issues on a large scale. On an individual level it is because people do not believe it is their responsibility, they believe it needs to happen somewhere they do not have influence over, they do not

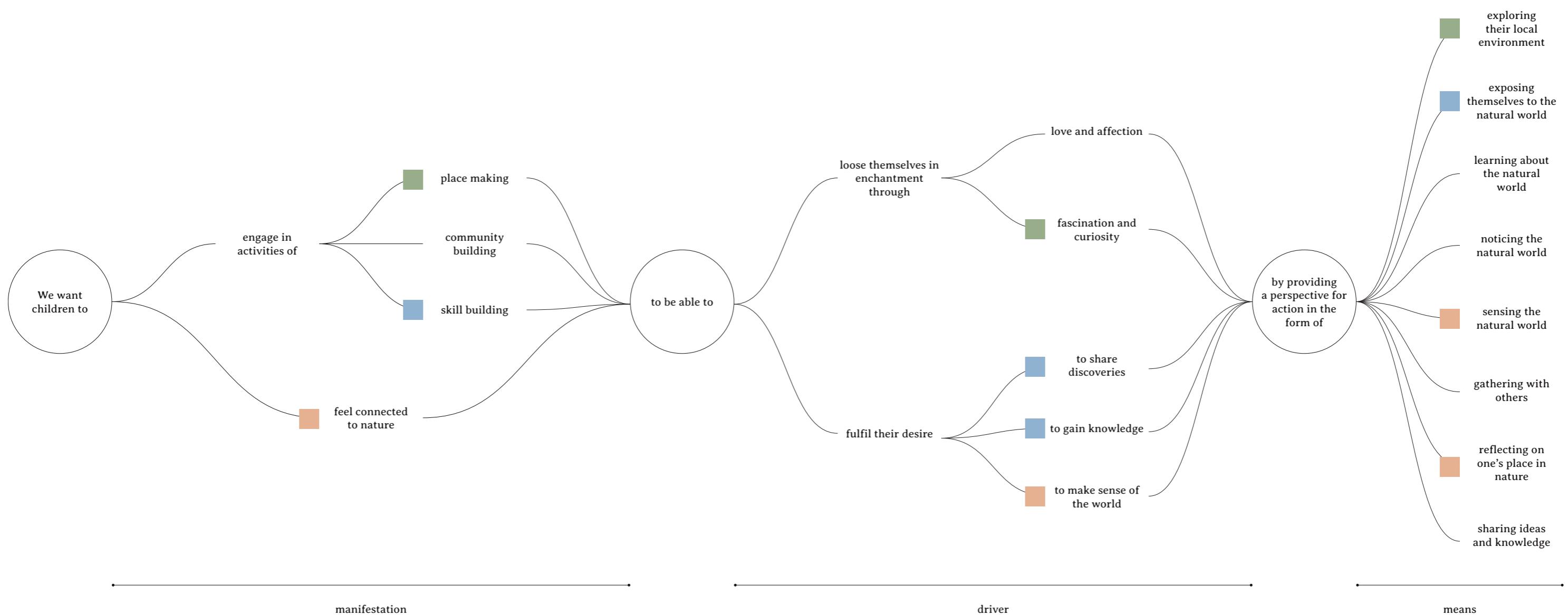
know what they can do, or that they feel like there is no right choice in actions.

desired situation Ideally Naturalis designs and facilitates products that enable the target audience to become a keystone citizen to unlock a desirable city ecology. The signatures of such a citizen are their expansive knowledge of the natural environment around them and their dependency on it, their skills in effectively engaging with the immediate environment around them and their strong connection to the nonhuman entities found in their local environment.

delimitation For this project we look for manifesting connection with the natural world and developing skills in carrying out a biodiversity positive attitude. To engage the target audience a series of engagement drivers can be appealed to, which have been selected based on the strategic priorities of Naturalis and the competences of the education department. This can be done through an array of different activities selected based on what the educational department can offer and develop best.

constraints As a starting point constraints in four areas have been formulated to guide the ideation process later on in the project. These four areas more or less reflect the identified stakeholders and their stakes in this project.

problem statement
“It is increasingly harder for children growing up in the urban environments of the Randstad to develop a biodiversity positive attitude based on experiences in their neighbourhood, inhibiting their becoming of a keystone citizen”



Designing for a keystone citizen

Having established a problem statement and a framework to design for the education in becoming biodiversity positive we can piece together an array of design goals. Here, I have used the syntax proposed by Hekkert and Van Dijk to formulate the appropriate “tracks” for Naturalis to investigate on their journey to provide children, or future citizens, with frames of action (2016). Figure 32 shows how these tracks form a chainable statement which can be used as a starting point for designing potential solutions to the problem definition. In the next chapter we will further unpack three of the tracks and see how that translates to a product concept in line with the different collected constraints and goals of the different stakeholders.

Figure 32. the design goal tree showing different design goals that contribute to investigating solutions for the problem statement

Chapter conclusion

This chapter can be seen as the bridge between theory and practice. Here we translated our research insights into a plan of approach by completing our problem definition and formulating appropriate design goals. Along the way we have seen how the education philosophy of constructionism and the more than human design perspective find common ground in the idealisation of a keystone citizen. This citizen is the embodiment of the biodiversity positive attitude. An individual that is engaged with their environment through actions, reflection and undersatnding. By creating a framework that breaks down what is necessary to become a keystone citizen we can start to synthesise our knowledge into actionable insights. Setting the stage for the next chapter.

RQ3.A

What does a biodiversity positive future look like?

A biodiversity-positive future is one where nature is deeply valued, not as a distant resource but as a shared space of life in which humans are active participants. Individuals are free to engage with nature through their own life frames, yet they acknowledge its essential role in their lives for food, wellbeing and economy. Citizens collectively shape their urban environments through activities such as citizen science, community decision making and urban gardening, contributing to an ecosystem that benefits both human and nonhuman species. Greenery permeates the urban landscape, creating spaces for meaningful encounters with nonhuman neighbours, while breaking the traditional divide between nature and culture. Institutions play a key role by providing knowledge and support, enabling communities to reclaim and co-create cities that are truly livable for all.

RQ3.B

How can we design for the development of a biodiversity positive attitude in 10-12 year olds?

Designing for a biodiversity-positive attitude in 10–12 year olds is fundamentally a question of becoming. Drawing on the Head, Heart, Hand model for transformative learning and the philosophy of constructionism, effective designs must create experiences that engage cognition, emotion, and action in tandem. This requires environments that frame the city as part of nature rather than separate from it, alongside opportunities for reflection, deepened understanding, and experimentation in real-world contexts. The Keystone Citizen framework, with its six manifestations of a biodiversity-positive attitude, provides a structure for connecting these elements, encompassing ongoing growth across the head-heart-hand spectrum. Expert consultations, workshops, and literature point to a range of potential means and motivational drivers that could contribute to these attitudes. Selecting and aligning these manifestations and drivers with design goals ensures purpose, focus, and meaningful engagement for this age group.



Species

Materialising design for a biodiversity positive attitude

Concepting approach
Exploring ideas
Concept direction evaluation
Design evolution
N=ZIEN
Evaluation

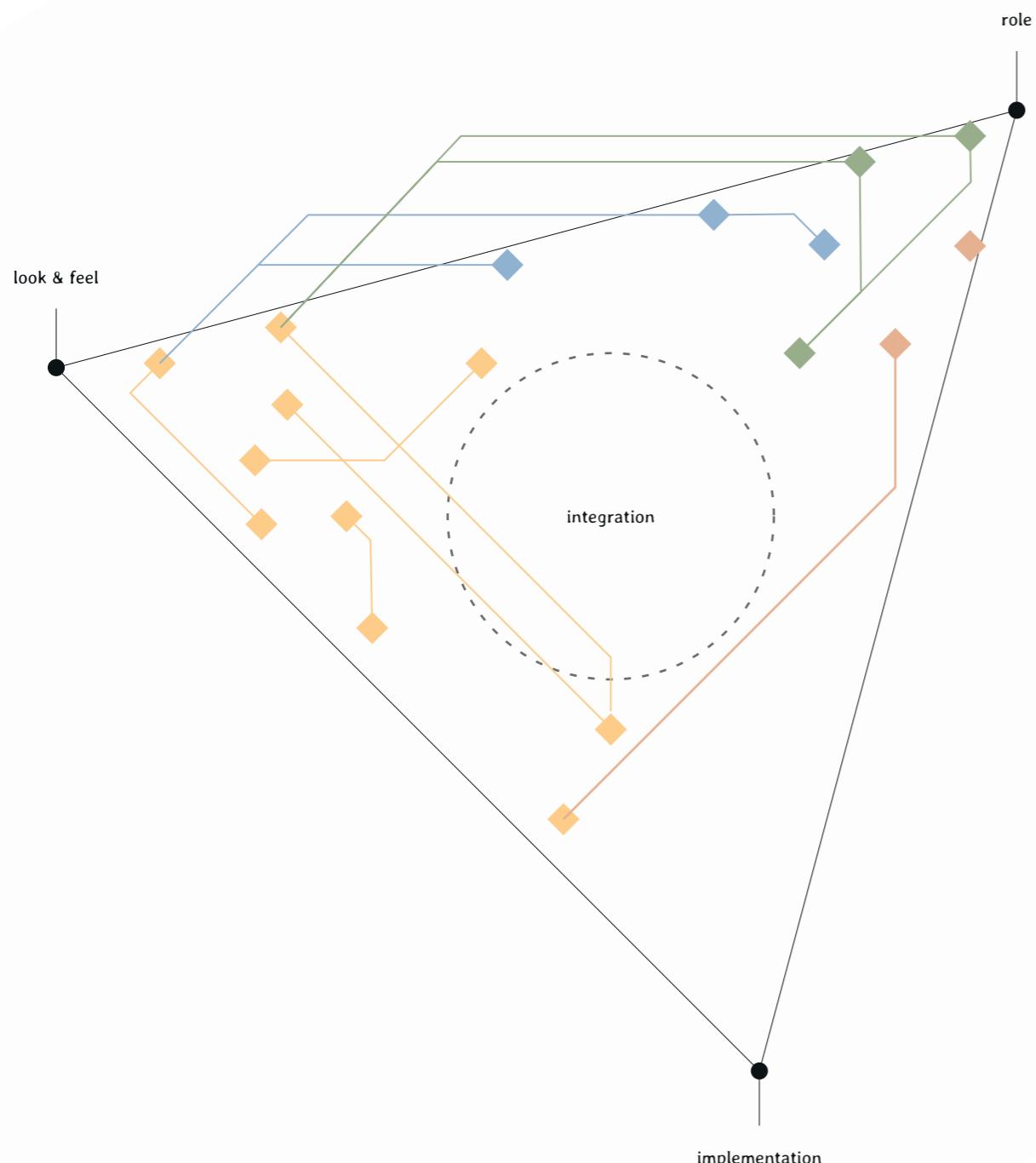
Figure 33. the beaks of birds are shaped in all kinds of ways to specialise in certain food sources making every species well adapted to the specific niche they fill.

This chapter aims to bring the research insights from the previous chapters into the real world by materialising a concept through sketching and prototyping. Drawing from Don Norman's user centered design approach, this chapter sets out to present the breath of ideation and exploration as well as the convergence towards the educational product concept: N=ZIEN. The first part addresses this exploration by presenting the iterative process of switching between sketching (Buxton, 2007) and prototyping (Houde & Hill, 1997); exploring and defining on three different tracks. After which the final concept is introduced and evaluated. With it gain insight into how our theories and synthesis can be applied in a real world context: the design of digital educational products for the education department of Naturalis.

RQ4.A: How can the unique resources of Naturalis contribute to the design of (digital) artefacts for 10-12-year-olds in the Randstad to foster a biodiversity positive attitude?

RQ4.B: How can we apply the keystone citizen framework to design artefacts that complement and encourage the development of a biodiversity positive attitude?

Concepting approach



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Figure 34. the prototyping model proposed by Houde and Hill with the different sketches and prototypes mapped onto it and their relations with regards to each other (1997).

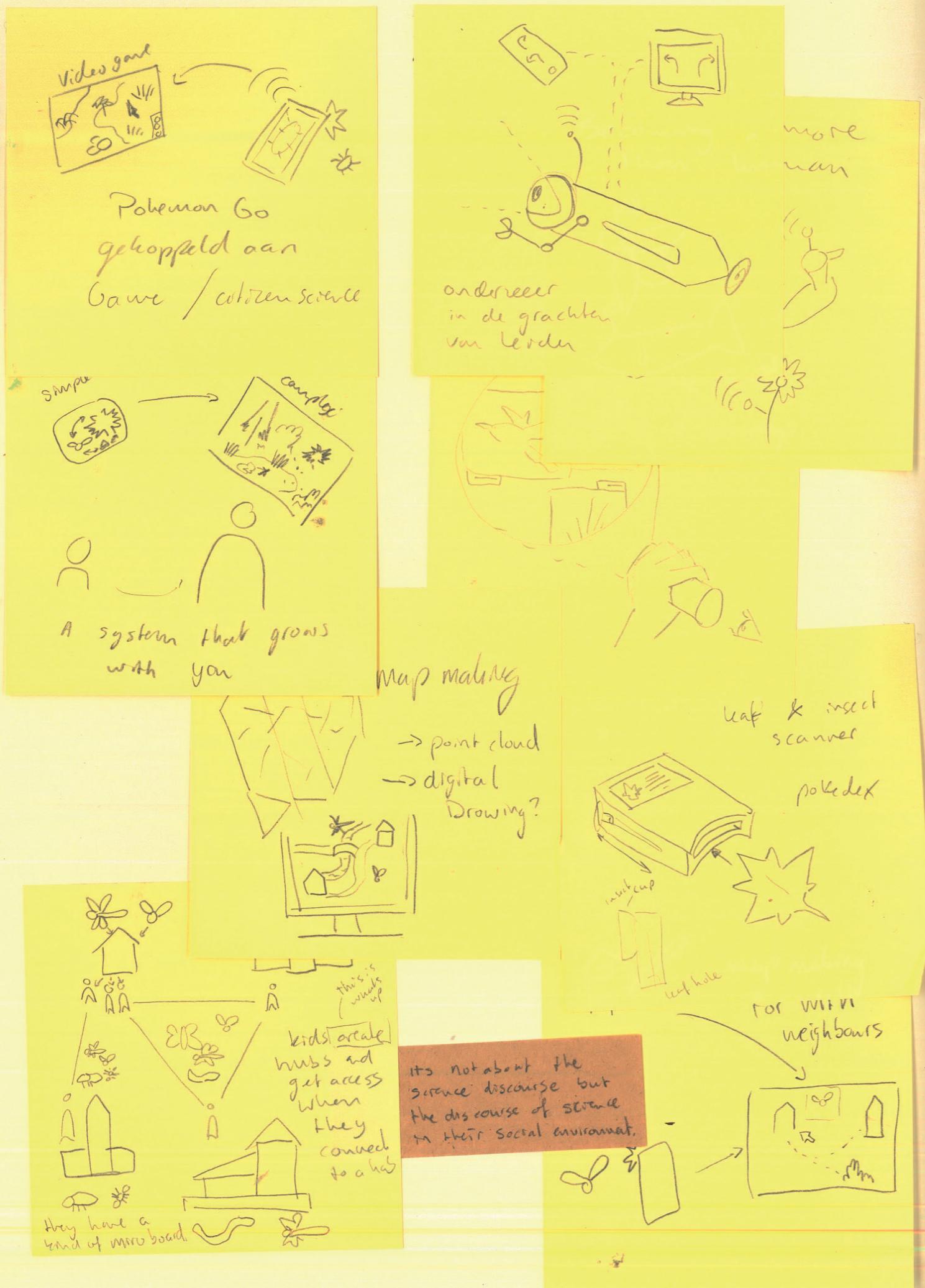
Having a solid foundation in the form of a thorough problem definition we can move on to the second part of our user-centered approach: generating numerous ideas (Norman, 2013). To narrow down on opportunities, three tracks were determined based on input from the education department. These three tracks formed the basis for three design directions that later were merged into one concept:

 place making	"We want children to engage in activities of place making to be able to lose themselves in enchantment through fascination and curiosity by providing a perspective for action in the form of exploring their local environment."
 skill building	"We want children to engage in activities of skill building to be able to fulfil their desire to share discoveries and to gain knowledge by providing a perspective for action in the form of exposing them to the natural world."
 nature connection	"We want children to feel connected to nature to be able to fulfil their desire to make sense of the world by providing a perspective for action in the form of sensing the natural world and reflecting on ones place in nature."
 final design concept	"We aim to foster a biodiversity-positive attitude in children (ages 10-12) by nurturing their nature connectedness and ecological literacy through an explorative citizen science experience that sparks curiosity, deepens their understanding of local biodiversity, and empowers them to take meaningful action."

These tracks were not only chosen based on input from the education department from Naturalis, they were also chosen for the diversity of possibilities they cover to keep initial insights into manifesting solutions for our problem definition broad. To investigate the suitability of the concept directions the framework proposed by Houde & Hill for prototyping was used (1997). Here it serves to point out the continuum that exists between sketches and **prototypes**, where created designs that explore and question bare more sketching qualities, while those that define and test are more prototype like (Buxton, 2007). The three design directions were investigated in parallel and finally merged into one concept direction. Figure 34 demonstrates how the different sketches and prototypes that informed the process can be mapped onto the framework proposed by Houde and Hill (1997). The final concept was evaluated by assessing the different design components separately.

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EARLY IDEAS



Generating numerous ideas

Norman invites user-centered designers to generate numerous ideas in order to have a wealth of possibilities to choose from (2013). For this project the ideation phase can be considered to consist of three parts:

1. preliminary ideas
2. design goal ideas
3. iteration ideas

Ideas that have popped up during the research phase unburdened by constraints (Figure 35).

Ideas that have been generated based on the different aspects of the design goal with constraints in mind.

Ideas that have emerged by iterating on design goal ideas based on the different collected frameworks from the literature study: life frames (IPBES et al., 2022), NQ quadrants (Van Den Berg et al., 2023), Passion pathways (Hecht & Crowley, 2019), the 6-pack (Naturalis Biodiversity Center, z.d.) and the insights from the nature connection handbook (Richardson & Butler, 2022)

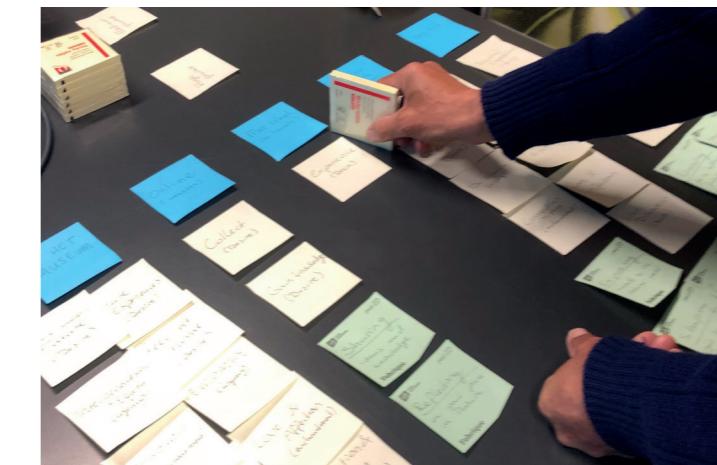


Figure 36.
coming up with ideas fitting promising manifestations, means and drivers together with members from the education department.

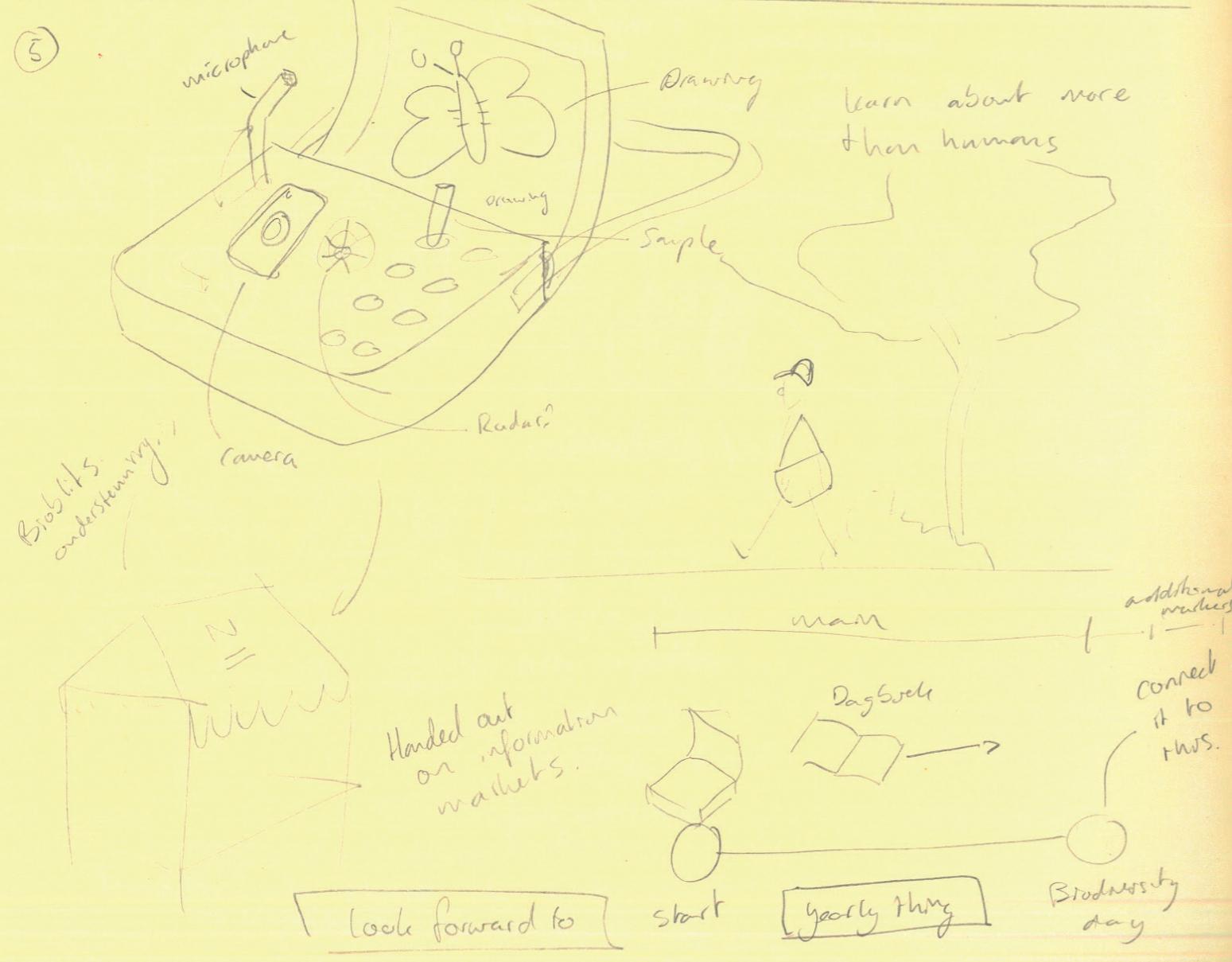
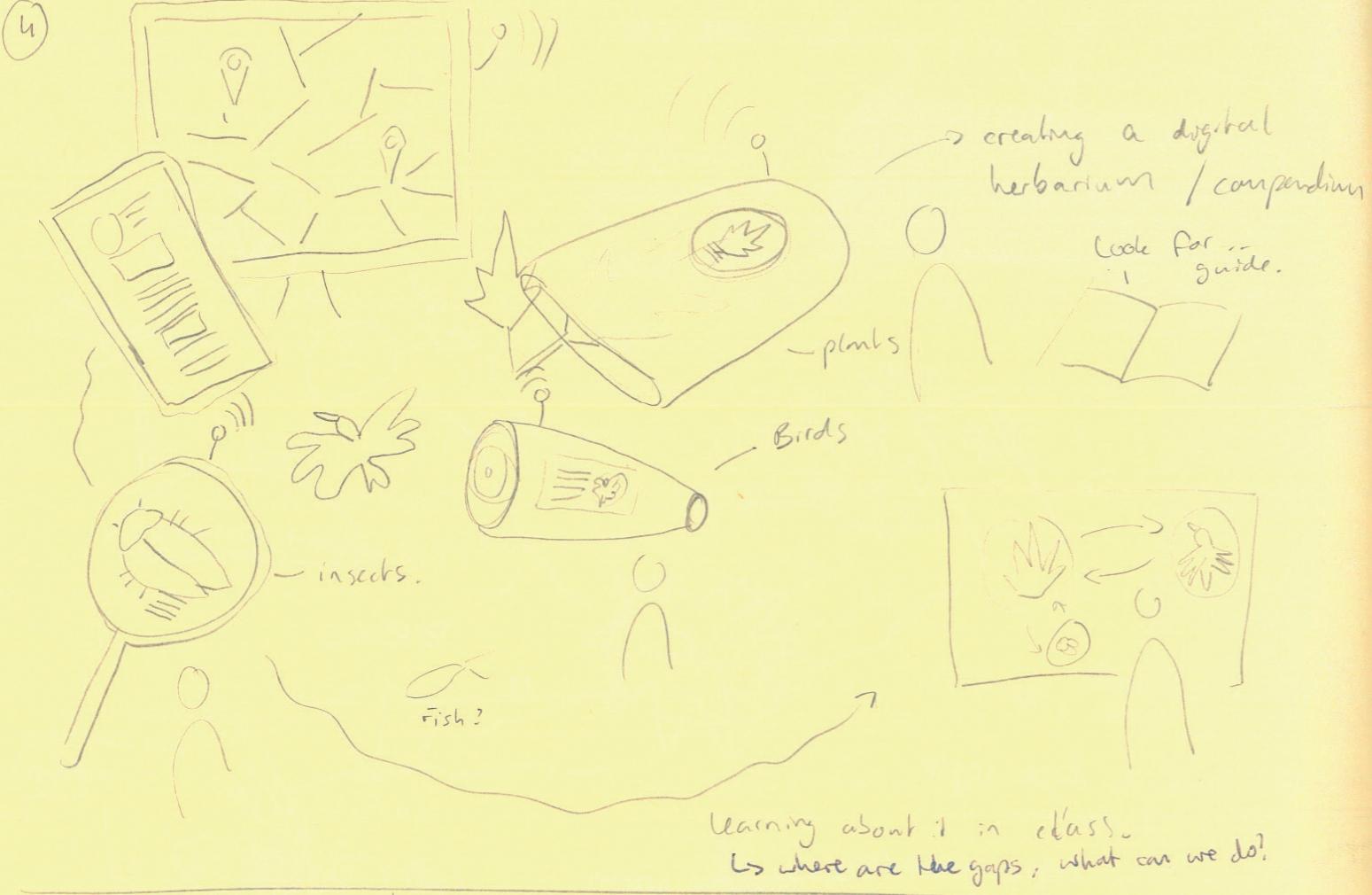
Although the preliminary ideas were mostly a solitary effort, the design goal ideas were informed by an ideation session with members from the education department from Naturalis and the iteration ideas were informed by a session with another designer.

The suitability of the ideas were assessed by clustering their underlying mechanics and mapping them to the three promising design goal tracks.

Figure 35.
a scan from the collected preliminary ideas

Towards three design directions

Based on the clusters of idea mechanics, the insights from the session with the education department and early assessment of feasibility seven ideas were worked out to design directions (Figure 37). These design directions were assessed on how well they fit the earlier established constraints and how they translate to the three chosen tracks to investigate. As mentioned before these tracks were chosen because they had different manifestations, means and drivers. This was done with the idea, that designing for a biodiversity positive attitude is new territory for the education department and that having three different tracks will create a broad exploration of how they can design to provide perspectives for action. For each of the tracks a design direction was chosen to investigate further.



N=SNAP

N=EXPLORE

N=SENSE

A biology curriculum for primary schools to investigate the more than human world around their house.

A mobile game encouraging children to encounter different species.

A family activity around using your senses leading up to biodiversity day.

Figure 37.
a scan from
some of the
initial design
directions

N=SNAP

N=SNAP is a seven week curriculum for grade 7 and 8 of primary school. During this curriculum pupils are tasked to find different organisms around their house and take photos of them with the N=SNAP device. These photo's are brought to class so they can indentify them during a biology lesson. After which the pupils learn about the anatomy of the type of life form they investigated that day. On the sixth lesson they compile all their findings into one map and investigate the gaps in the **food web**.

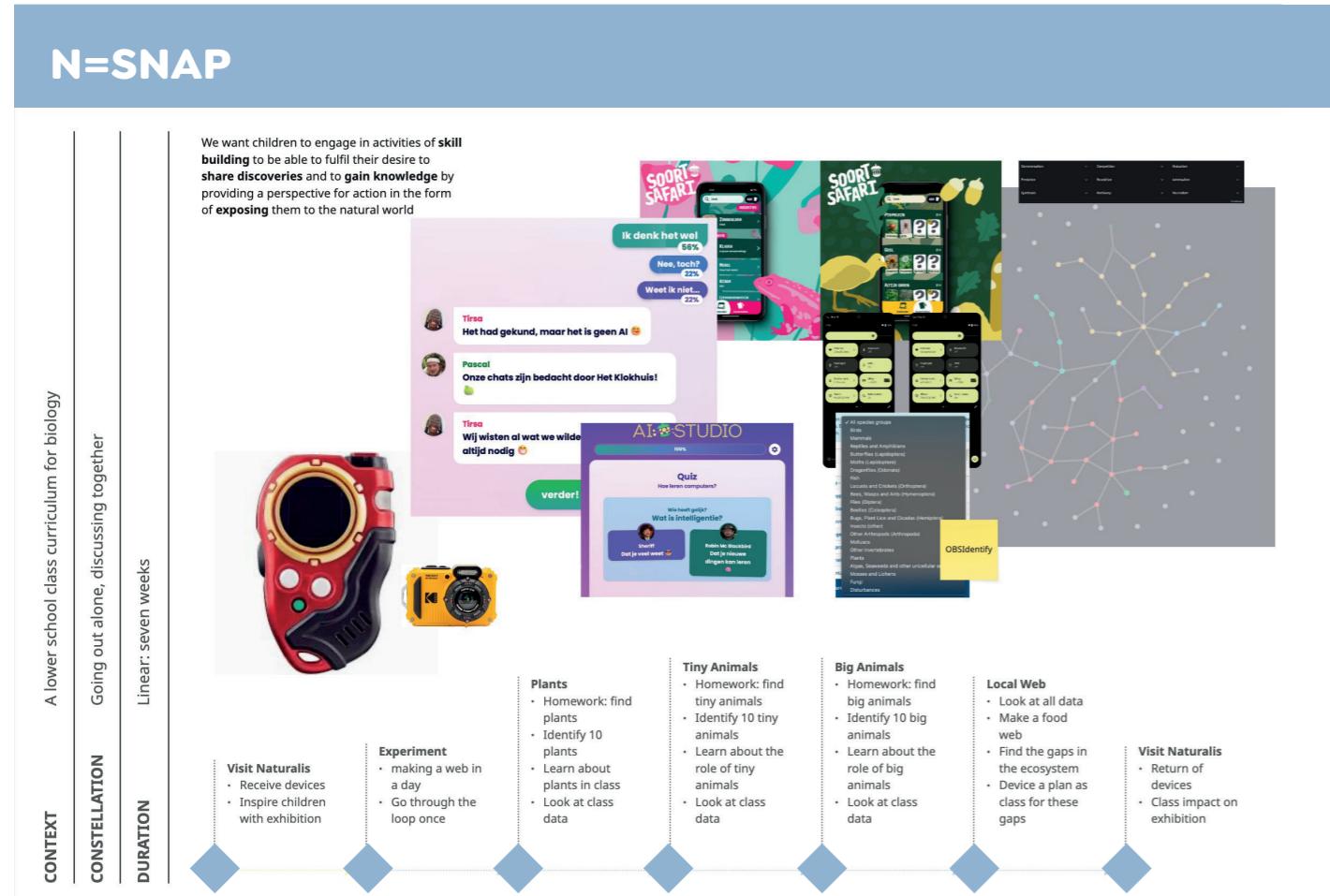


Figure 38. design direction sheet to communicate ideas to stakeholders

design goal

"We want children to engage in activities of **skill building** to be able to fulfill their desire to **share discoveries** and to **gain knowledge** by providing a perspective for action by **exposing** them to the natural world"

skill building

Refers to the manifestation of the biodiversity positive attitude as "social skills" targeted at more than humans and how well they can identify nonhumans.

share discoveries

Refers to the desire of children to share things they have found and learned with each other and adults..

gain knowledge

Refers to the desire of children to learn new things and to expand on a domain of knowledge they know more about than their parents.

exposing

Refers to the means that is used to achieve the other aspects, in this case by both having the user perceive that they are interacting with an element of nature as well as the sensation that they are part of it.

context

Primary school biology curriculum

constellation

Individual excursion, group discussions

duration

Seven lessons [lineair]

medium

Handheld device, web application

Inspiration

This track was inspired by different applications, most notably Soortsafari, OBSIdentify and Klokhuis AI studio:

- The design requires you to go outside [Soortsafari, OBSIdentify].
- The use of AI for education [Klokhuis AI studio].
- Users are prompted to think for themselves [Klokhuis AI Studio].
- The aesthetics are simplified and easy to understand [Soortsafari, Klokhuis AI studio].
- The design allows you to contribute to a bigger picture (citizen science) [OBSIdentify].

N=EXPLORE

N=EXPLORE consists of a gameplay loop that combines going out into the neighbourhood to find different species with being a steward for your own digital ecosystem. The species that are found in the real world become accessible in the digital environment. The digital environment consists of a plot of land that is managed by the player by planting vegetation and meeting requirements of certain species to enter the plot of land.



Figure 39. design direction sheet to communicate ideas to stakeholders

design goal

We want children to engage in activities of **place making** to be able to lose themselves in enchantment through **fascination and curiosity** by providing frames of action in the form of **exploring** their local environment

place making

Refers to learning about and understanding the meaning an environment has and developing attachment to that environment.

fascination & curiosity

Refers to the drive of children to lose themselves in finding out all there is to know and following intuitions in the quest for it.

exploring

Refers to mapping out what there is to find in an environment and experiencing an environment with a sense of adventure.

context

In the neighbourhood

constellation

Individual or together

duration

Indefinitely [loop]

medium

Smart phone application

Inspiration

This track was inspired by different games such as Pokemon Go, Viva Pinata and Animal Crossing:

- The design should be a cosy experience to take the time for wonder and following your interests [Viva Pinata, Animal Crossing].
- The design uses geolocation to generate contents for the game [Pokemon Go].
- The design is connected with real-life institutes for additional content [Pokemon Go].
- The design requires users to interact with the real world in order to play the game [Pokemon Go].
- The design has a low-poly aesthetic to match the cosy game setting [Animal Crossing].

N=SENSE

N=EXPLORE consists of a gameplay loop that combines going out into the neighbourhood to find different species with being a steward for your own digital ecosystem. The species that are found in the real world become accessible in the digital environment. The digital environment consists of a plot of land that is managed by the player by planting vegetation and meeting requirements of certain species to enter the plot of land.



Figure 40. design direction sheet to communicate ideas to stakeholders

design goal

We want children to feel **connected to nature** to be able to fulfil their desire to **make sense** of the world by providing a perspective for action in the form of **sensing** the natural world and **reflecting** on one's place in nature.

nature connection

Refers to the degree to which the individual perceives themselves as part of the natural world and active participant in it.

making sense

Refers to the need of children to understand how the world around them works and how they can maneuver in it.

sensing

Refers to the use of the embodied senses (sight, smell, taste, hearing, touch) to experience the natural world.

reflecting

Refers to the active thought on what it means to be part of the world and what their actions mean to the world around them.

context

in the neighbourhood

constellation

with the family

duration

30 days [Linear]

medium

smartphone application, web application

Inspiration

This track was inspired by different applications, mainly Mini Motorways, Kahoot! and Polarsteps:

- The product should be designed as a festive board game, inviting a sense of excitement [Kahoot!].
- The design should have implied and soft aesthetics to make it easy to understand and approachable [Mini Motorways].
- The design allows users to fill in a map to create a satisfying experience about getting to know an environment [Polarsteps, Mini Motorways].
- The design hosts interactive maps [Polarsteps].

Design direction evaluation

Based on the iterative sketching and prototyping of the three tracks and the evaluation of the tracks based on the constraints list several insights were gained. In addition to the embodied insights the concepts were evaluated with the education department and several three designers (two academics and one professional). These insights together formed the starting point for drafting a new design goal to kickstart the design process for the final concept. Below the main insights are discussed in relation to the constraints of the project.

Digital compatibility

One of the most defining insights is the apparent contradiction of digital tools and experiential dialogue. In the concept evaluation sessions the N=SENSE concept demonstrated that digital tools stood in the way of interacting with each other. It was theorised that this concept would work best as an analog product and therefore it is not fit for this particular project. Additionally, the N=EXPLORE, while completely digital, stood further away from the existing digital product portfolio. This makes it hard to connect the different environments, making the concept direction less suitable for continuation.

Learning vs fun

An important part of developing frames of action is the acquisition of knowledge and insight. These require, to some degree, the learning of new things. To have the product be successful it needs to strike a balance between being fun to use and being informative. The N=EXPLORE concept, investigated the potential for Naturalis to provide a tool that would be used in leisure time by the children. A concept that was conceptualised with gamification principles in mind to encourage a playful experience. However, this would also mean that it will have to compete with alternative leisure activities, meaning that it has to be fun enough to be chosen. In the concept evaluations concerns were raised about the ability of such a tool to still stay informative and provide a frame of action. N=SENSE on the other hand was

perceived to feel more like homework, since it does not have a defined incentive for all participants (guardians and children). On the other hand, providing an excursion instead of a class was perceived as more fun. This makes it easier for a concept such as N=SNAP to compete with counterparts.

Maps over webs

Both the map-maker and island maker were received well in the concept evaluations, especially in combination with a collaborative element. The island maker from the N=EXPLORE concept was perceived to be a more intuitive and situated representation of knowledge than the generated web in N=SNAP (Figure 41). However during the prototyping of the N=SENSE map-maker the complexity of making a stylised mapmaker suited for children to draw their own maps of the neighbourhood became apparent, making it not particularly suited for the goal that was set for it.

Citizen science as a medium

During the synthesis of the insights collected by evaluating the concept directions I came to realise that citizen science embodies most of the qualities that we are looking for. Biodiversity citizen science invites users to go outside, to learn, to perceive and to share. It also gives activities meaning beyond the act, by adding to a shared database. The open-ended nature of citizen science projects also allow participants to follow their own interest, keeping the things they learn about close to what they feel connected to. Finally, it helps in understanding the relation between species and place, by bringing ecological knowledge to the real world.

School as starting point

These three tracks looked at three different contexts: primary schools, free time, family time. Based on the evaluations with different experts, the primary school context seemed most appropriate to situate the project in. We have already seen in the Ecology chapter that one of the challenges that educators face is developing programmes that aid in shaping effective participants for

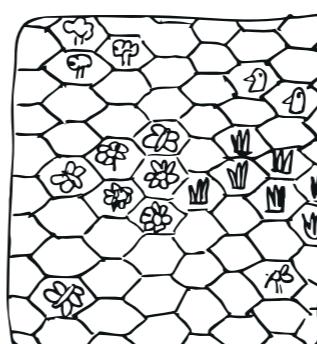
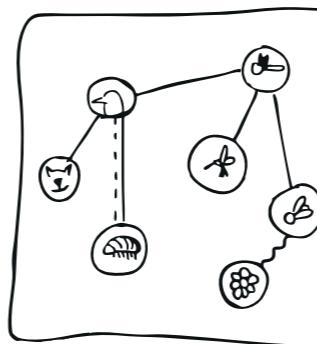


Figure 41. the three ways maps are depicted in the concept directions

a biodiversity positive future (Capra, 2007). Additionally, one of the education experts consulted for this project earlier pointed out that there are not equal opportunities for children to engage with nature. Children with guardians who engage little with nature activities show less ecological literacy, van den Berg et al. suggest that nature education and activities organised from schools may provide a means to mitigate these inequalities (2023). Additionally, this provides a shared experience for the students, which they can reflect on together, even after finishing the lessons. Therefore, developing educational products that can be used at schools appear to have more impact than those developed for other scenarios.

design goal:

“We aim to foster a biodiversity-positive attitude in children (ages 10–12) by nurturing their nature connectedness and ecological literacy through an explorative citizen science experience that sparks curiosity, deepens their understanding of local biodiversity, and empowers them to take meaningful action.”

Design goal reformulation

Compiling the insights from the exploration of the three tracks, several aims emerge which we can rewrite into a new design goal..

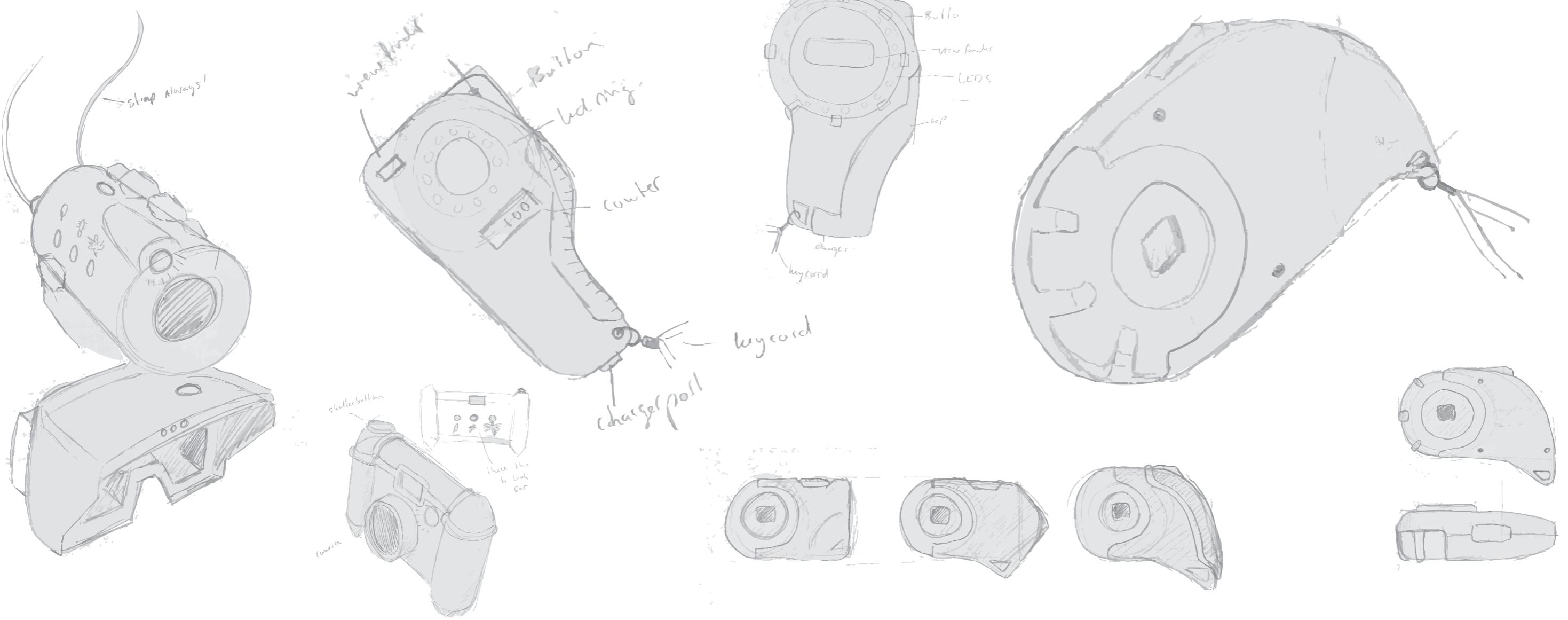
Ambitions for the future	More nature connectedness and skill because it makes people have a biodiversity positive attitude.
What approach do we take	Skill in getting to know nonhumans and understanding each organism's role in the web of life including your own and providing frames of action realisable by the target audience.
Which activities does that translate to	Through exploring the environment in new ways, exposing to nature, making an environment a place of meaning and learning about the nonhumans and their preferences.
What narrative speaks to the target audience	Citizen science helps to get to know your immediate environment, to provide insight what you can do for it it also extends the meaning of the activity beyond doing the activity itself and provides purpose for engaging with the activity.
Which driving forces are engaged	Besides the mission of the citizen science framing, it allows them to make sense of the world, gain knowledge, share discoveries and follow their curiosity.

ambitions on a societal level We aim to foster a biodiversity-positive attitude in children (ages 10–12)

manifestation of the attitude by nurturing their nature connectedness and ecological literacy

means of engagement through an explorative citizen science experience that sparks curiosity, deepens their understanding of local biodiversity, and empowers them

engaged personal driver to take meaningful action.



Design evolution

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Based on the insights collected through sketching and prototyping the three concept directions and the newly formulated design goal, an iterative process was started to find the form factor and format for a concept that combined the merits of N=SNAP, N=SENSE and N=EXPLORE (Figure 42). While Figure 42 and 43 only depict the exploration done for the design of a handheld device, The same was done for the visualisation of maps and the guidelines for a chat environment.

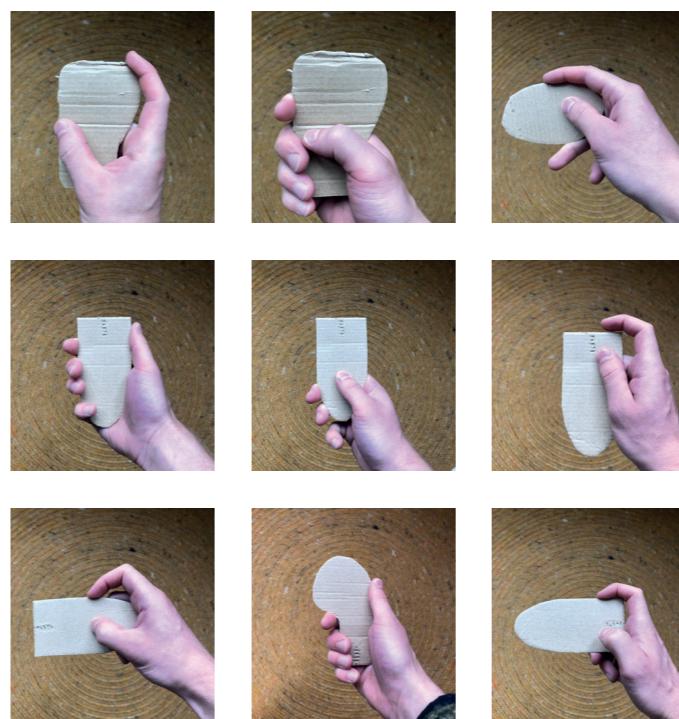


Figure 43.
exploration of
form in tandem
with sketching

Figure 42. a glimpse of the convergence from the three concept directions to the final design

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Figure 45. a mockup of the N=ZIEN device

N=ZIEN

N=ZIEN is an education platform and physical device that aims to help urban children build skills in engaging with nonhumans and boost the sense of nature connection these individuals have. In this concept the students of grade 7 and 8 are tasked to use citizen science to analyse the biodiversity in the local environment and to come up with ways to improve the area. The concept prioritises that the knowledge is generated by the students themselves for them to gain a better understanding of how the world around them works.

The first lesson focuses on the introduction of different concepts like citizen science and the idea that nature is all around us. This is put into practice by marking out the area that they will research.

In the following lessons three different kinds of organisms are introduced consecutively; plants, invertebrates, vertebrates. Based on these introductions to the organisms the students go out in duo's with a physical device (Figure 45) in a marked area to find and photograph different species to log their observation. Back in the classroom they enter a chat environment that prompts them to identify the species they have found. Throughout this chat they not only learn what species it is, but also what their role is in the ecosystem and what their features can tell you about that.

In the final lesson the students compile all the observations in one map. Through a series of questions that lead to the web being filled with information useful for doing an ecological network analysis, the students are finally asked to identify weak points in the web that has emerged. And formulate a plan with the class on how to strengthen the web.

To be complete in the description of and to further elaborate on the manifestation of the N=ZIEN product concept the model presented by van Kuijk on the product use context will be used to structure the following paragraphs (2024) to provide a complete overview of the findings (Figure 44).

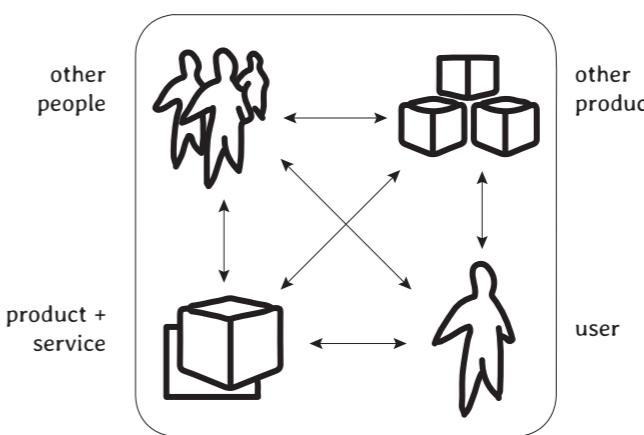


Figure 44. a schematic view of the components used to deconstruct the N=ZIEN concept based on the model proposed by Wever et al. (2008)

Context of use:
Other people:
User:
Other products:
Product + Service:

urban environment, delft as case study
visitors in the museum, parents
children (ages 10-12), teachers
digibord, laptops, digital portfolio of Naturalis
N=ZIEN device, website, docker



Users

Earlier it was already established that children (ages 10-12) will be the target audience. However, now that there is a clear context of use, additional research was done to better understand how the needs of the students translate to design requirements for this specific concept. Additionally, the setting of a school adds another primary user to the product service ecosystem: the teacher. Figure 46 provides a schematic on which design elements are shared and which are not between these users.

Primary school pupils

To better understand the needs of children in this specific context I participated in two test sessions with children (ages 8-12) hosted by Naturalis for other products and consulted an associate professor in designing for child's play. This further validated the earlier drafted constraints.

And added several new insights which have been translated to design requirements. Primarily, disappointment is to be avoided as this kills the joy of going out and being on an adventure. In addition it was recommended that the students engage with the physical device together as it will prompt discussion among themselves and will improve the quality of the photographs taken. Below the earlier drafted constraints and the new insights have been compiled to a set of requirements for the interaction with the concept.

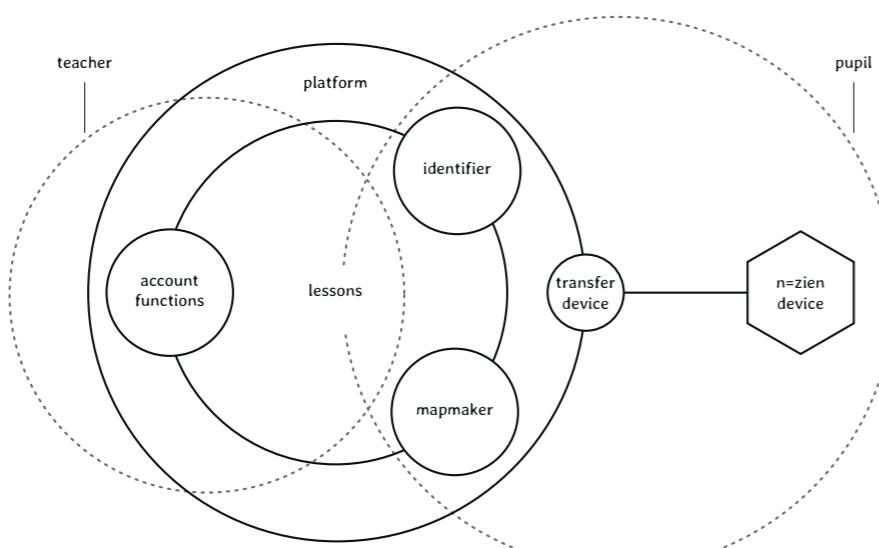


Figure 46.
a schematic
showing how
the different
design elements
are used by
teachers and
students

Primary school teachers

The other primary users of the product service system are the teachers. They are expected to set up the environment and function as course guides throughout the five lessons. To understand the needs of teachers in this particular context, I inquired indirectly about their preferences. Based on input from the education department and an expert in designing for child's play the following design requirements for the physical and digital product have emerged.

pupils

confirmed constraints

- The design builds up step by step
- The design conveys a neutral message (not positive not negative)
- The design acknowledges the agency of children
- The design combines physical activity with cognitive activity
- The design is engaging to use

digital requirements

- The design lets the user generate knowledge
- The design only supports when the student is unable to reach a correct conclusion

physical requirements

- The design needs to convey whether an image is usable or not for the identification
- The design needs to support going out in groups
- The design needs clear communication on what is happening

teachers

digital requirements

- The design does not require students to make an account
- The design is self explanatory
- The design requires as little setting up time as possible
- The design does not require basic knowledge from the teacher

physical requirements

- The design features a seamless transfer of photographs between the N=ZIEN devices and the digital environment
- The design does not require the class to visit Naturalis more than once



Other people

Apart from primary users, secondary users can be considered. These individuals interact with both (parts of) the platform both direct and indirect without them being the primary target audience. While not being the focus, taking them into account in the design of the platform may enrich the overall experience for more people

Classmates

The main secondary users to consider are fellow classmates. Each student will engage with the concept either in the marked area with other students or in the classroom. As mentioned before, going out in groups generally improves the quality of the work, this is enabled by the discussions that may arise when a task has to be completed together.

Museum visitors

The contributed observations are ideally linked to the upcoming biodiversity exhibition in the museum. This allows students to see what their class contribution can look like during the visit to Naturalis. Additionally it invites the idea that they have contributed to a piece of Naturalis which may be exciting for them to see if they revisit the museum. This interaction has been little explored but breathes potential in connecting the students more with the museum.

Role models from Naturalis

Having actual experts from Naturalis connected to the assignment allows on the one hand for the students to feel taken seriously. Their actions will have an impact on the museum and these researchers are keen for the data they have collected. Additionally, in the consultation with a researcher on nature and development for children, mentioned that memorable experiences are often connected to meaningful role models. Therefore introducing such a role model may enhance the experience all together.

Parents & guardians

Ideally the students also bring their insights home, so in the design of the lessons and the frames of action that emerge based on the web analysis it is interesting to look at elements that may be appealing to both the guardians and the children. This thesis has not explored where this overlap can be found, but it could form an integral part in actualising change early on.

Other schools

At the end of establishing the web a class can contribute their data to a larger database containing all the observations collected by other schools. There is a very loose one way interaction here that could be further explored, but that has been left unexplored for this thesis.

digital requirements

- The design provides insight into the relation between the findings of the student and those of the class.

physical requirements

- The design invites sharing sightings among peers
- The device invites discussion among peers

Other products

The concept builds on several assumptions surrounding other products. The most crucial assumptions are those of assumed available material. Notably, that per duo (at least) the students have access to a laptop or computer, that the teacher can use a digital whiteboard and that students are not permitted to use their smartphones. Although these are standard in most Dutch classrooms, if Naturalis desires to expand their teaching material beyond the Netherlands this might become a concern.



/ Kerndoelen primair onderwijs 2006

Kerndoelen Oriëntatie op jezelf en de wereld

Natuur en techniek

Kerndoel 40
De leerlingen leren in de eigen omgeving veel voorkomende planten en dieren onderscheiden en benoemen en leren hoe ze functioneren in hun leefomgeving.

Kerndoel 41
De leerlingen leren over de bouw van planten, dieren en mensen en over de vorm en functie van hun onderdelen.

Kerndoel 42
De leerlingen leren onderzoek doen aan materialen en natuurkundige verschijnselen, zoals licht, geluid, elektriciteit, kracht, magnetisme en temperatuur.

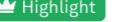
Kerndoel 43
De leerlingen leren hoe je weer en klimaat kunt beschrijven met behulp van temperatuur, neerslag en wind.

Kerndoel 44
De leerlingen leren bij producten uit hun eigen omgeving relaties te leggen tussen de werking, de vorm en het materialgebruik.

Kerndoel 45
De leerlingen leren oplossingen voor technische problemen te ontwerpen, deze uit te voeren en te evalueren.

Kerndoel 46
De leerlingen leren daarnaast de natuurverschijnselen : 

10:39 idt tot

20 

RGM.792000
To be found in gallery "Dinosaur era"

slo

Explore more
On Natuurwijzer (in Dutch)


De holle botten van vogels
Vogels hebben holle botten. Dankzij deze botten zijn ze licht, waardoor...


Dinosaurussen in je achtertuin
Dinosaurussen stierven ongeveer 66 miljoen jaar geleden uit, waars...



Figure 48. page from the SLO learning goals guide (SLO, 2006)

Figure 47.
screenshot from
the Naturalis
app linking to
Natuurwijzer

digital
requirements

- The design is suitable for both Laptop, tablet and Digiboard screens
- The design is tailored to the SLO learning goals [39, 40, 41, 44, 45]
- The design is interconnected with the other digital products from Naturalis

Context of use

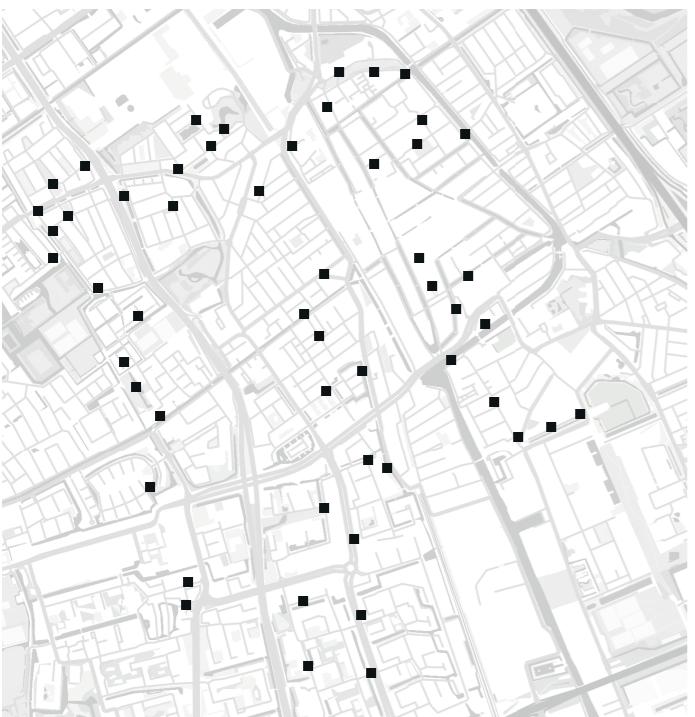
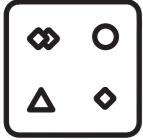


Figure 49. different locations visited to gain a better understanding of the urban environment

digital requirements

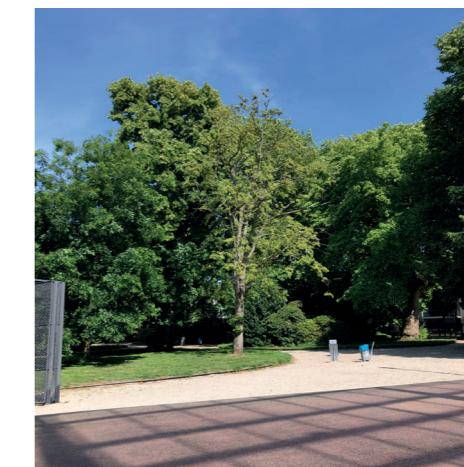
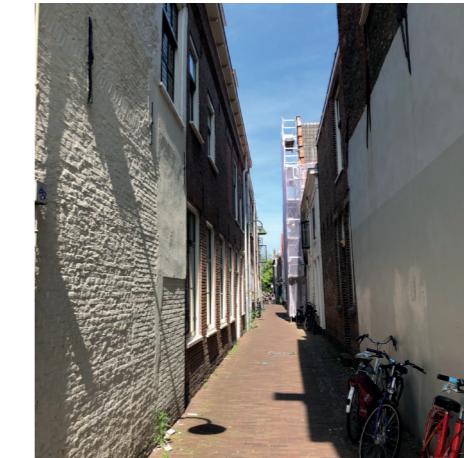
- The design informs teachers what to look out for in selecting an appropriate location.

physical requirements

- The design requires scouting the area of research before the actual identification cycles start.

Now that we have a scenario we can further investigate the context of use. This entails the cultural, social and physical environment. In the earlier chapters we investigated the socio-cultural characteristics of the environment, but now that we have a clear setting for the concept we can investigate the physical context as well. As a case study the different neighbourhoods of Delft have been studied by cycling through the neighbourhoods and taking photographs (Figure 49). This revealed the importance of selecting a good location for the concept to work effectively and which revealed five factors to consider in the selection of the area of study (Figure 50). Based on these insights the introduction lesson has been altered to have the students mark the area of research together. This provides two benefits for the rest of the concept. First, it allows them to become familiar with the environment and scan for interesting places to visit next time they are outside. Second, to make sure that the selected area is appropriate for the other lessons by running the checklist provided beforehand.

With a marked area that is not dangerous, contains some degree of greenery, some degree of diversity, provides opportunity for changes and is accessible we have a good location. Examples are for instance public parks close to the school, the school courtyard and the ecotones next to rivers and canals. This has led to following design requirements for the introduction lesson.



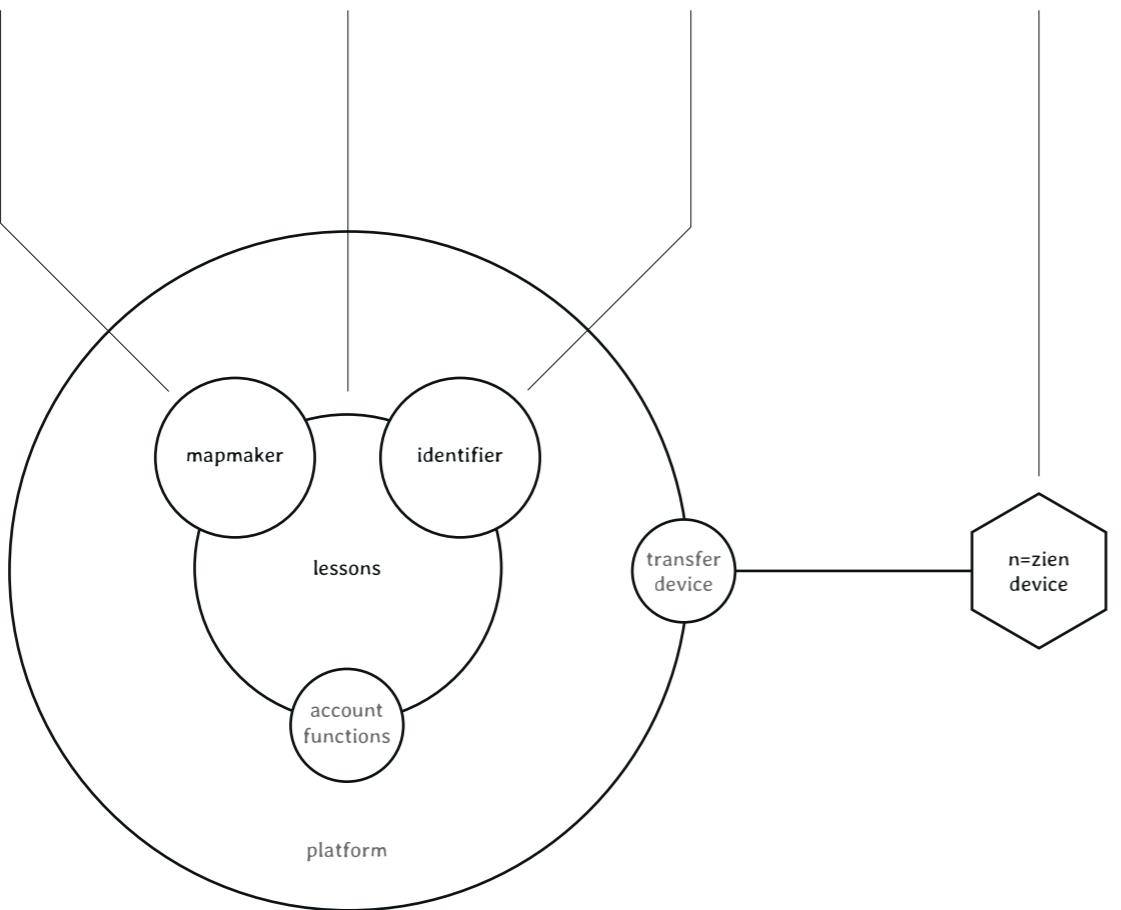
1. Danger Is there a risk of traffic accidents or drowning?
2. Greenery To what extent is the environment green?
3. Diversity How diverse are the elements that make up the environment?
4. Opportunity Is there a possibility for the pupils to change the environment?
5. Accessibility How much of the environment is publicly accessible?

Figure 50. five photographs demonstrating the five criteria for selecting an appropriate location.

selected areas at least need some degree of greenery to be investigated

some areas are suitable but can not be subjected to change limiting possible perspectives for action

Product



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Figure 51. overview of the different design elements of the N=ZIEN platform

The concept can be divided into a digital component and a physical component. In Figure 51 the different components are presented in a schematic manner. In the following paragraphs these components are elaborated on in greater detail and are evaluated based on their respective goals within the larger goal of the concept.

Platform

The N=ZIEN platform is a digital environment that runs in the browser. Similar to Kahoot, only the teacher has to have an account and the students can join with a passcode. This passcode is unique to the students, allowing the teacher to still see individual progress without compromising personal data. The platform hosts the five lessons, the identifier and neighbourhood web interface.

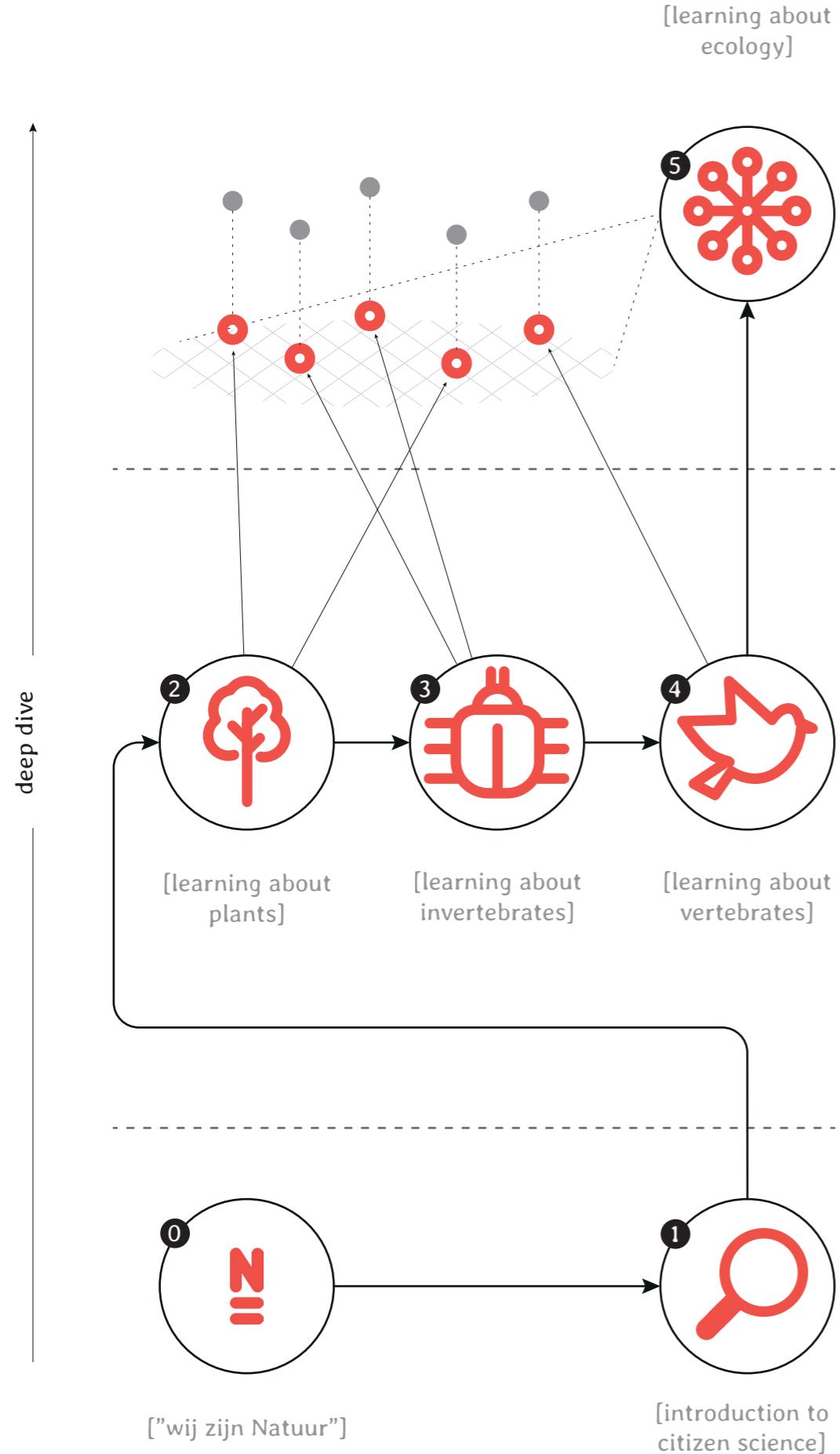
Device

To attain photographs of nonhumans while respecting Dutch law prohibiting smart phone use in classes (Ministerie van Algemene Zaken, 2024), the N=ZIEN device has been conceptualised. A device that is both meant to fill the gap that smart phones could fill as well as to provide an exciting yet serious context for the students.

In the following paragraphs the different design components from the complete N=ZIEN platform are elaborated on and evaluated.

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Figure 52.
lesson
structure



Lessons

The N=ZIEN concept consists of one excursion and five lessons. These lessons are crafted to follow up on each other, with each having a distinct purpose in how it contributes to the overall design goals. An overview of these lessons can be found in Figure 52. This part is about the contents of the lessons and how the other products flow in and out of use. In the following paragraphs a more in depth explanation is given about the specific purpose of each lesson and how the content should make that possible.

Lesson 0: **Excursion to Naturalis**

The visit has three purposes: to inspire students with nature's diversity and show humans as part of it. Through "Wij zijn natuur", they learn about interconnected life, a good introduction before their own exploration. Linking their observations to the biodiversity exhibition can show how their findings contribute to a larger citizen science network, adding meaning. Finally, it is a practical moment to collect the N=ZIEN devices from teachers and give further explanation if needed.

Lesson 1: **Introduction to citizen science**

The introduction lesson sets the stage for the rest of the program by familiarizing students with key terms and sensitizing them to upcoming topics. By the end, they should understand the goal of the N=ZIEN lesson package, what citizen science entails, and that nature exists in urban environments. They will also have developed an initial awareness of nature, while becoming familiar with the research area. The lesson consists of three parts: introducing N=ZIEN, sharing prior experiences, and scouting the research location.

Lesson 2-4: **Identifying species**

The three lessons follow the same structure but focus on different organisms: plants (lesson 2), vertebrates (lesson 3), and invertebrates (lesson 4). Each invites students to perceive nature in new ways. We start with plants, as they are easy to find and photograph while forming the essential foundation of the food web. Students learn to see plants as more than background scenery. Vertebrates encourage noticing familiar animals with fresh attention, while invertebrates require the most skill, as they are small, fast, and elusive. Together, these lessons ensure students explore their neighborhood, engage with nature, improve their ability to recognize nonhuman life, contribute observations, and adopt a new way of seeing their environment. Each lesson consists of four steps: introducing the organisms, searching for them, identifying and learning about the species, and relating them to the local environment.

Lesson 5: **Building a neighbourhood web**

The final lesson brings all observations together in a web-like visualization, allowing students to share discoveries and identify actions to improve local biodiversity. Its purpose is to teach students about species interrelations, the elements of a healthy ecosystem, scientific thinking, and recognizing opportunities for biodiversity enhancement. The lesson consists of three parts: filling the web, analyzing it, and developing a frame of action.



Figure 53. screenshot from a digital sketch

Evaluation

Although the content creation did not fall within the scope of the project, the lesson buildup was still evaluated in three ways. Primarily it was evaluated informally with the education department of Naturalis during project updates. Additionally, it was evaluated by prototyping user interfaces in Figma. Finally it was also evaluated in two concept evaluation sessions, one of which was with an education team of a smaller biodiversity center. During this session one of the participants also mentioned the NME Den Haag guide for Climate and Nature education. After the session it was interesting to see that most of the insights gathered throughout this project were also stated in this booklet, providing an extra source of validation for the educational assumptions (z.d.).

Insights

- Making a curriculum that covers multiple learning goals makes it likelier to be adopted.
- Making a curriculum that fits both project weeks and regular lessons may increase its likeliness for adoption
- Content development needs to be done in close collaboration with experts.

Identifier

In the lessons 2 - 4 the students identify species by collecting photographs and identifying them in a chat environment (Figure 54). This process consists of a chain of events (Figure 55). This process contributes to building skill in identifying nonhumans, knowing where to find them and what they mean for the environment. Additionally, the act of looking for them encourages exploration and making sense of the environment.

In this paragraph we zoom in on the digital experience of chatting to discover what species we are dealing with. Extra attention for this part is necessary since this is where the knowledge gained from the environment comes to meet the theoretic knowledge. This allows students to situate the theoretic knowledge and give more meaning to the situated knowledge. Based on the constraints and requirements three areas are of particular interest in this process.

Figure 55. flow of the identification lessons

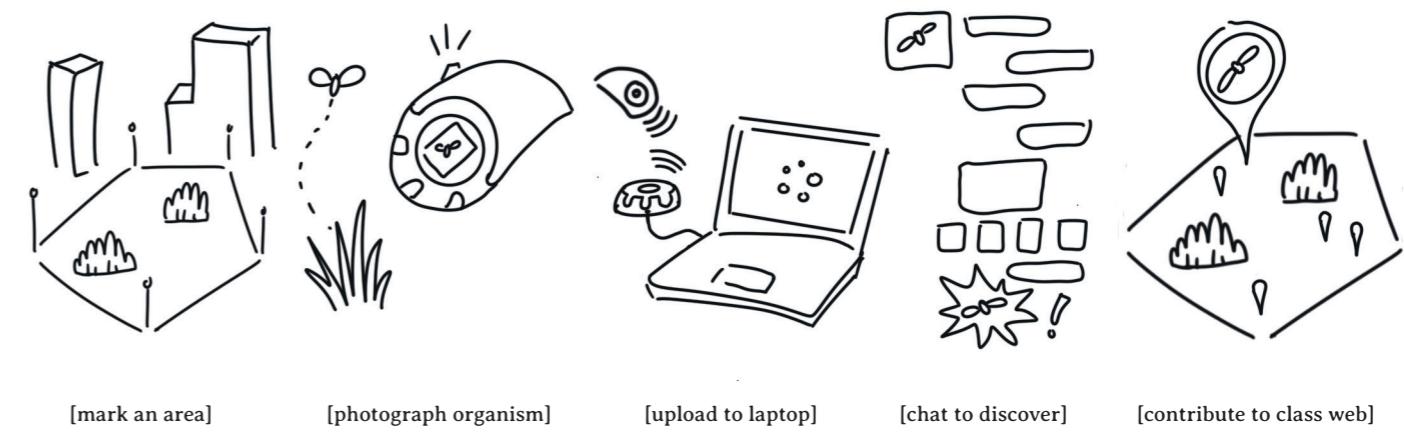


Figure 54. a mockup of the chat environment

Beyond taxonomy

In addition to interaction patterns that help with defining the taxonomy of an organism, it may even be more important to link the knowledge to the world. In the example of the wings of bugs and beetles, this is brought further by prompting why the student thinks they have developed hardened wings. This starts a conversation about the role of beetles in the ecosystem and their relation to other nonhumans. Other areas where this is possible are for instance the form of a beak, the form of the feet of birds, the colouring of animals, the shape of the teeth etc.

Mastering your own knowledge

The chat functions as an aid for students to generate their own knowledge. Therefore it is desirable for the chat to reveal as little information about the species as possible that might prevent the student from coming to their own conclusions. This has led to the chat being able to interact with the user in several interaction patterns:

Open questions Preferably the chat requires the student to answer open-ended questions that prompt them to connect known information (e.g. "What do you already know about this animal?").

True / False questions To provide the user with additional information in the form of "fun facts" true or false questions are used if the student overlooked something (e.g. "What do you think, spiders can be recognised by the lack of antennae? True or False?). It also provides an extra opportunity for indirect interaction with other pupils by showing percentages of their reactions.

Contextual questions In some cases the student will need some contextual or additional information, for instance in determining whether something is a bug or a beetle, here the chat provides the necessary information on how to make that distinction (eg. "In general beetles have hardened shells over their wings, while bugs don't, can you figure out which the species in your photo has?")

Image based questions In some cases the student needs to compare things to figure out what they are dealing with and to learn what to look out for. This interaction provides four images that are similar but can be distinguished.

Keeping track

It is also important to keep track of significant information this is done by both keeping track of the identified characteristics of what makes this species this species as well a prompt at the end of the chat: e.g. "So next time you're out in the wild, what will you look out for to identify beetles?"

...

Good observation! It really has that wasp-like coloring with yellow and black.

Here's a fun fact: some flies copy the colors of wasps to scare predators, even though they can't sting.

If you look closely at the eyes, what do you see? Are they big and round (like fly eyes), or smaller like a wasp's?

Exactly! Those big, round eyes are a strong clue that this is actually a fly, not a real wasp.

Would you like me to show you a few pictures of similar flies and wasps side by side, so we can compare the details?

*not actual images 

Here are some real-life examples of wasp-mimicking hoverflies, just like your insect! Notice the yellow-and-black stripes, the one pair of wings, and especially the big round eyes —they match what we saw in your photos.

Now, let's look a bit closer:
Do you see any long antennae sticking out from the front of its head? Hoverflies often have shorter, stubby ones—some wasp mimics even have long feelers.

Can you spot them in your photos?

Nice spotting! If you see longer antennae, it might be a clue that this is not just any hoverfly but one of the wasp-mimicking hoverflies that really try to copy the wasp look.

Another detail:
Do you see a thin "waist" like wasps have, or is the body more straight and chunky like a fly's body?

Ooh, interesting! A thin "waist" is a real wasp feature, but some hoverflies are really good at faking it.

Let's test another clue:
When you look at the wings, do you see any dark patterns or are they completely clear?

...

wasp

big

yes

yes

wasp

dark patterns

Figure 56.
fragment from
user test at
Naturalis

Evaluation

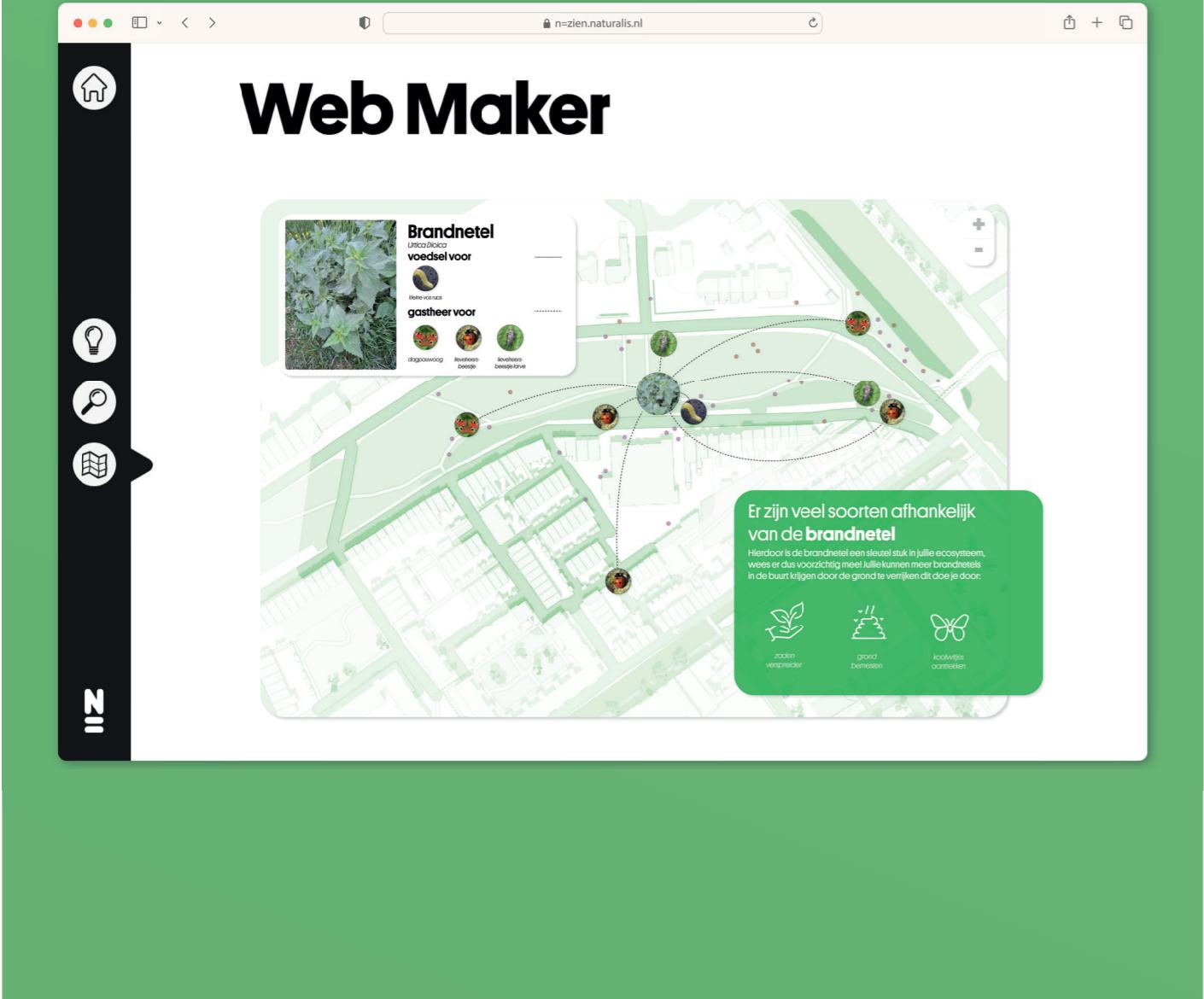
This process was evaluated on four occasions to validate the design as both functional and capable of enhancing ecological literacy. During auto-ethnographic testing, I attempted to draft clear guidelines for the large language model, but achieving the desired interaction proved challenging. This difficulty arose partly because the model did not consistently follow instructions and partly because I struggled to clearly define the distinctions between different types of information. A pilot test with one participant with a design background helped identify shortcomings I had overlooked, particularly in the flow of taking and uploading photos. It also confirmed that users preferred information about a species' role in the ecosystem over strict taxonomy. In nine user tests with Naturalis visitors of varying ages, participants selected one of five prepared image sets to identify, which revealed that minimal text and image-heavy content were most effective. Finally, concept evaluations with a representative from observation.org and a team of educators from another biodiversity center highlighted the identifier as the most promising element of the N=ZIEN platform, likely due to its lower complexity and more developed design compared to other components.

Insights

- The chat needs to only provide the bare minimum information for the user to come to a conclusion.
- The chat needs to allow for the user to make their own assumptions.
- The chat needs to incorporate information about the role of the organism in the ecosystem
- The chat needs to always show the images taken by the user.
- The chat needs to keep track of discoveries made by the user.
- The chat needs to limit how much the user should read.
- The chat needs to aim to identify a species within 10 minutes.
- The chat needs to be clear in its communication.
- The chat needs to prioritise image based questions
- The chat needs to shy away from open ended questions.
- The chat prompts the user to think about the way the world works.

Web maker

In the final lesson the students build a neighbourhood web with all the observations they have done combined. The data of the species has already been added to the web. However, during this lesson they will also add the relationships among species by answering different questions about the system and analyse the ecosystem as a whole in groups. Here the visualisation of the web plays an important part in the way that students can interact with it and draw conclusions from it.



Tying it together

The interaction with the neighbourhood web does not only function as a means to figure out frames of action. It is also a means for students to share insights with each other and to put their observations in perspective. During the identification process they may have learned of birds having a certain beak which tells something

about the food source, but in this experience they can use that knowledge to guess at the relationships between the found species. This further grounds their knowledge in the local environment. Additionally, it gives more meaning to the environment as it becomes more apparent why certain species appear in the places they were found. Through it these places become known and functional.

Figure 57. a mockup of the map tool

Introduction to ecological network theory

Although it will not be introduced as such the students will engage with ecological network thinking. In an ecological network species (nodes) are linked with each other that describe the interaction (vertices). To describe these we can draw from the standard framework for mapping interspecies relations (van Wilgen, 2020). However, here I have made a choice to omit neutral relations, as they may make the map more complex than necessary. In addition to being able to describe the network on an individual (single node) and relational level (connection between nodes), an analysis of the whole network can be done (systemic)(Figure 58). While making an ecological network can be used to analyse ecosystem stability, in relation to this project it also serves two other purposes. On the one hand it introduces the students to scientific thinking. On the other hand the activity serves as a means to introduce the students to the complexity of the world from a networked perspective. It provides a visualisation of the relations that run through their environment.

Data fragmentation

For the final lesson the class will be working with the data they have collected in the area they have selected. As the students will use the N=ZIEN device in duo's, this means that with an average class size of 24 (Ministerie van Algemene Zaken, 2021), there will be around 180 observations. Some of these will overlap, so depending on the likelihood that the species overlaps the system will have to be corrected for them. Additionally, we have to consider that the students might mainly report preference species (those with the prettiest flowers, the slowest movement, the most tameness etc.) Therefore, we can't use the dataset without its sidenotes. Rather than perceiving this as a limitation I see it as an opportunity to show that scientific research always operates within boundaries. So, while we will not be able to reliably conclude the health of the ecosystem, the web does generate data that can be used by the pupils for perspective of action:

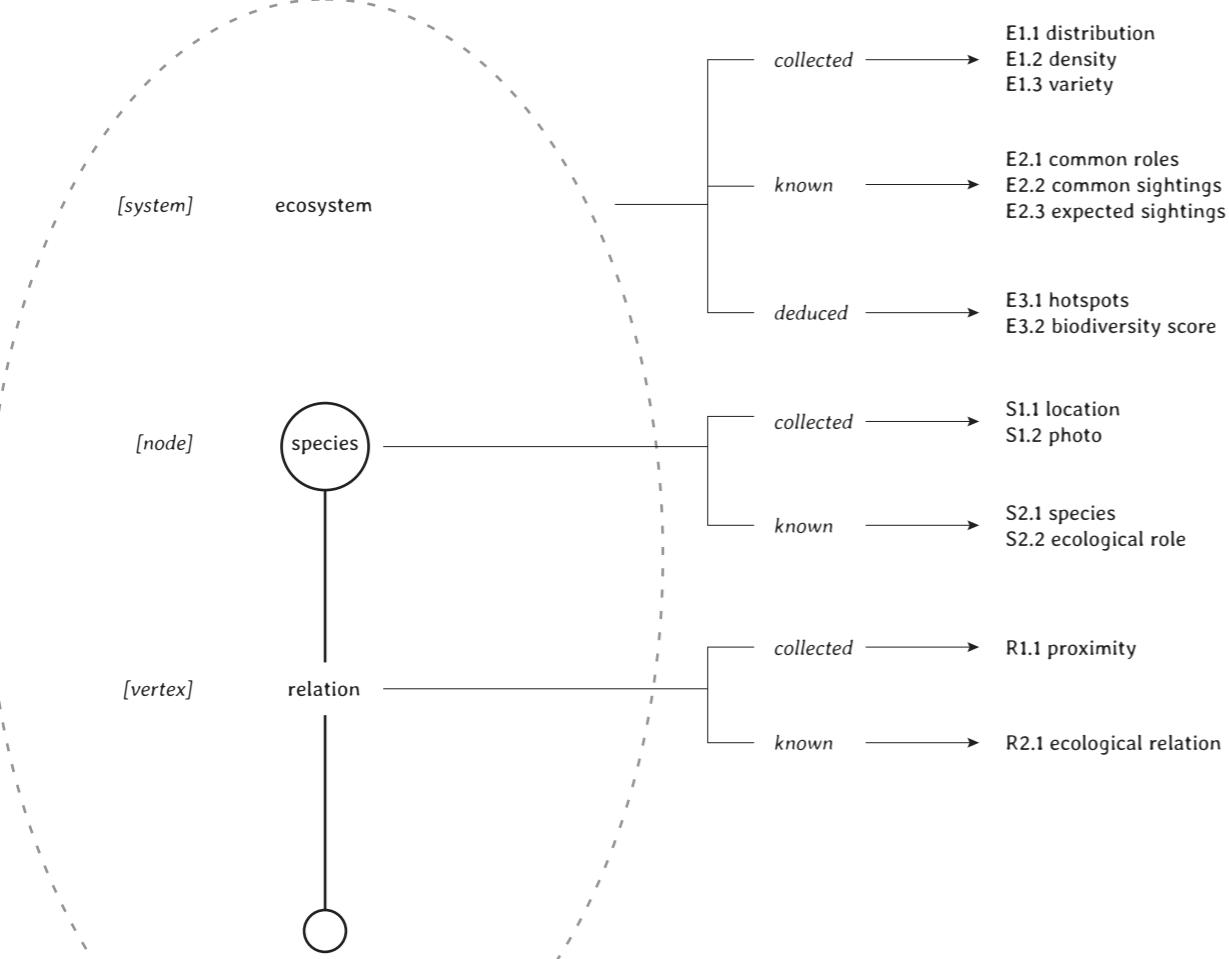


Figure 58. a schematic view the data types collected and made for the web maker

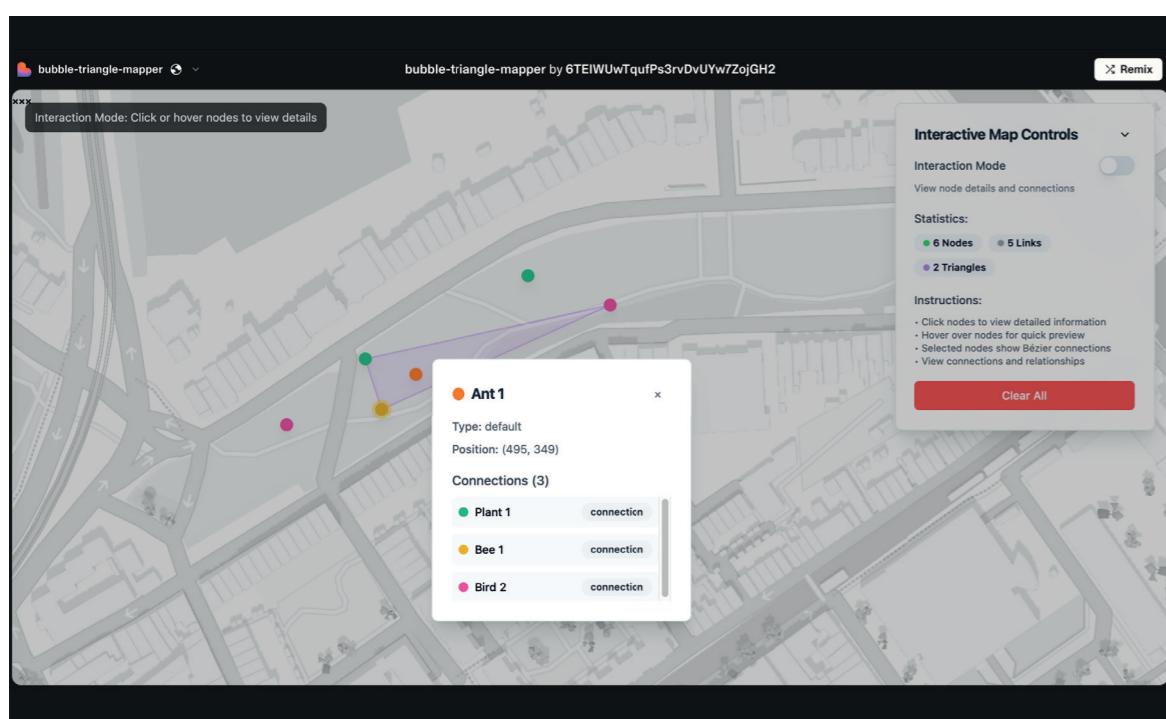
Species [variety]: Number describing the amount of species found
Species [density]: Heatmap describing the density of different species

Species [common]: List describing the most sighted species
Species [missing]: List describing the expected but not found species

Roles [frequency]: List describing which species roles are most observed

Habitat [variety]: Clusters describing unique constellations of species
Habitat [hotspot]: Heatmap describing the amount of sightings

Biodiversity score [simplified]: Number that summarises all of the above in one





Device

To map the environment we need observations and for observations N=ZIEN uses photographs with locational data. To acquire these, pupils go outside in a predetermined area and photograph species with the N=ZIEN device (Figure 61)

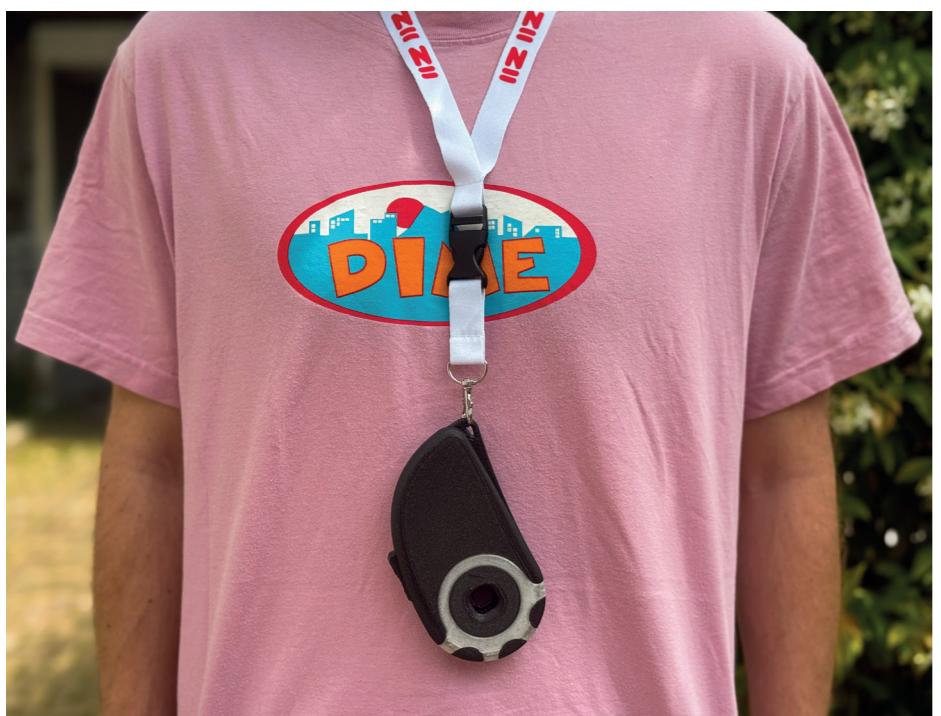
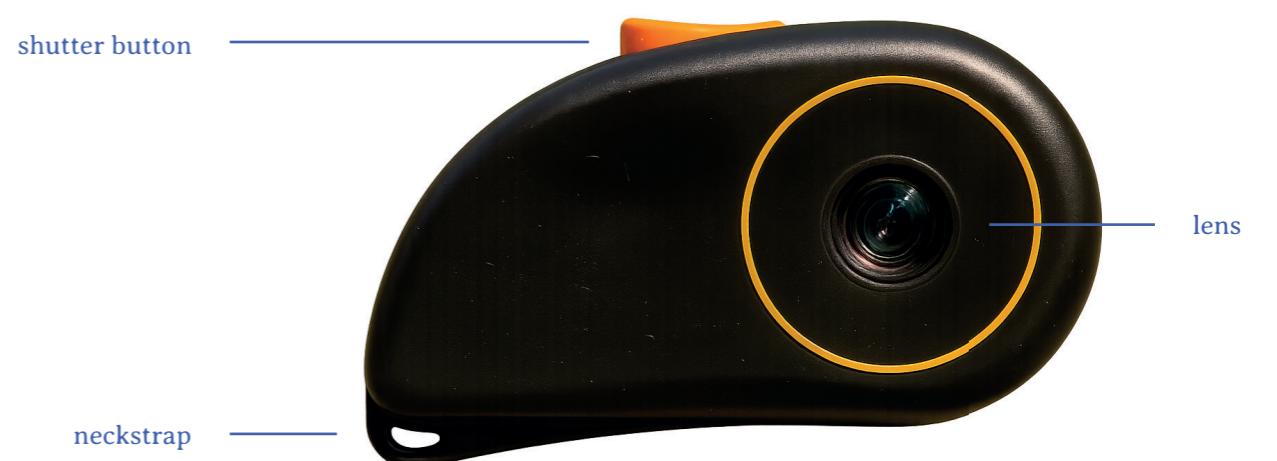


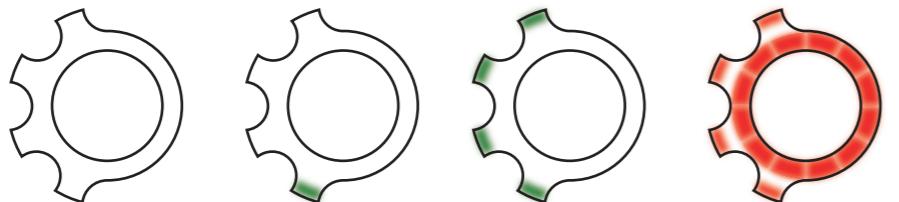
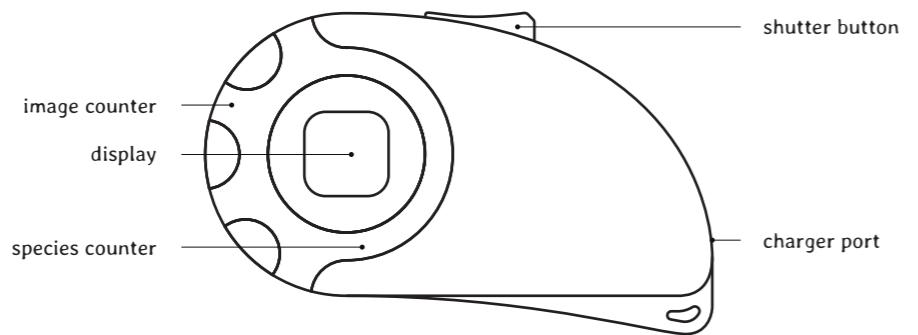
Figure 62. a mockup of the N=ZIEN device

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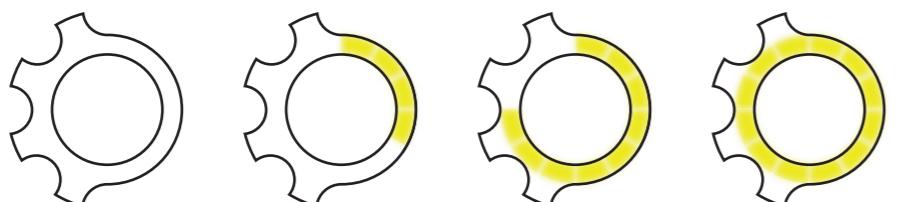


133

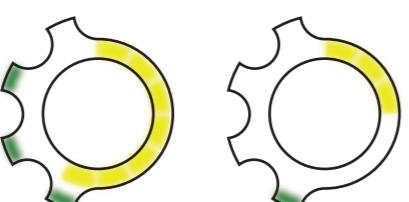
Figure 63. a mockup of the N=ZIEN device



[00 / 04] [01 / 04] [04 / 04] [05 / 04]



[00 / 12] [04 / 12] [09 / 12] [12 / 12]



[03 / 04] [01 / 04]

[07 / 12] [03 / 12]

Interaction

The purpose of this device is quite simple: to be able to make observations of the nonhumans in the designated research area. To make this a smooth experience several constraints and requirements have been collected and translated to the following interaction pattern. The device consists of two inputs: a button for taking photographs and a dial to navigate the interface (Figure 64).

Interaction

One important constraint is that the device needs to prevent disappointment, because there is a risk that the photographs that are taken are not identifiable. To mitigate this a display has been added. This display allows the students to see what will be saved to the camera roll, it provides a guide on where to capture the subject and it allows the students to revisit and erase photographs.

Seamless data transfer

Another consideration is the transfer of the photographs from the device to the web environment. To facilitate an easy transfer and to limit technicalities a dongle for the teachers computer has been thought out, though only sketched. This bluetooth device is pre-paired with the N=ZIEN devices. While the teacher is logged in to their N=ZIEN account they can open the “upload images environment”. The website is able to check for connected devices creating a bridge between the devices and the computer, without having to pair all of the devices separately. By tapping the devices onto the dongle it starts transferring the images from the device to the web account.

Discussion

Additionally, the device will be shared between two students. This means we can use the device to prompt discussion in order to improve the quality of the observations as well as to feed the exchange of knowledge. This is done by allowing only 12 observations, each containing up to 4 images (Figure 64). This requires students to think about which images to take and which not to take and to discuss them.

Figure 64. an explanation of the device interface

Figure 66. demonstration of viewfinder enactment



Evaluation

The evaluation aimed to assess whether the artefact was appropriate according to Arkel and Tromp's aesthetic, moral, and contextual axes, as well as whether it was engaging to use. During the test session at Naturalis, I formulated accessible questions to gain insight into how users perceived these abstract parameters. The

aesthetic axis revealed that the new form factor, while interesting, was sometimes confusing and required extra explanation. On the moral axis, participants found it difficult to understand its relevance, while the contextual axis depended on whether photo-taking between participants was permitted. The neck cord, however, was perceived as convenient. Engagement was limited, as I did not observe particular interest in the device, and older children expressed a preference for using a smartphone, with one noting it would be more fun to use with friends. A pilot test with one design professional investigated

the form factor and user flow in a lesson context, which led to adjustments such as changing the LED lights to better match the theme. Finally, a product evaluation at Naturalis, structured around Arkel's framework and conducted with a fill-in sheet, confirmed both the strengths and weaknesses of the concept.

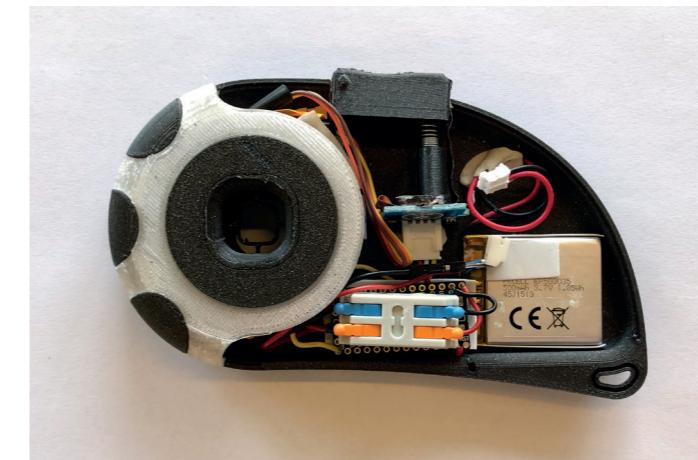


Figure 68. a peek into the electronics of the N=ZIEN device prototype

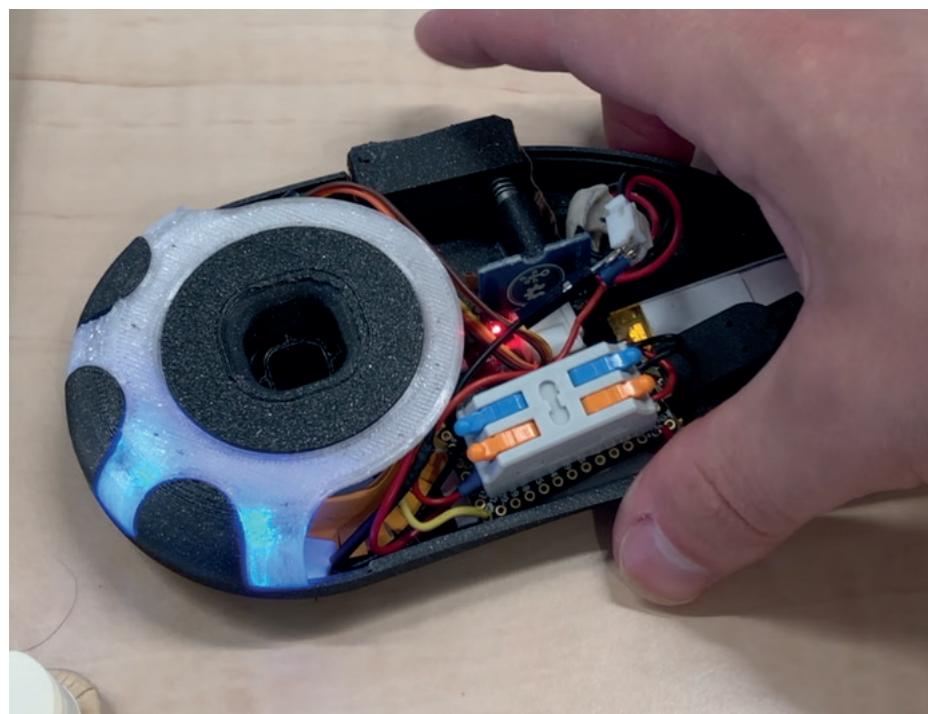
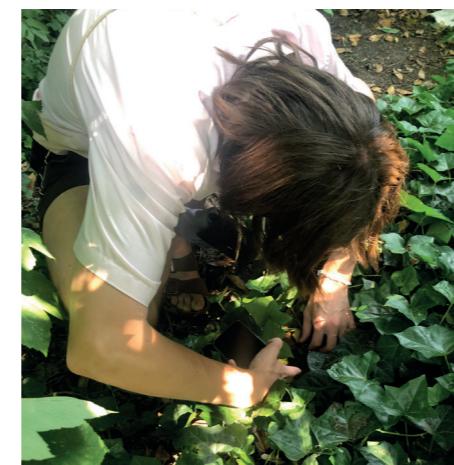


Figure 67. pilot participant using digital prototype to find species of bugs

Figure 65. demonstration of the LEDs



Insights

- The device needs to communicate whether an image can be successfully identified.
- The device needs to show what the user is photographing.
- The device needs to be sturdy and water proof.
- The device needs to be conventional.
- The explanation of use needs to be simple.

Overall evaluation

Although the N=ZIEN platform has not been evaluated as a whole we will make an attempt at doing so by looking at the different evaluation sessions that were done to investigate the different parts of the concept. To provide some structure, we return to the design constraints that were established as part of the problem definition.

More-than-human perspective

1.1 *The design promotes the idea that nature is an actor in its own right.*

By investigating the different roles organisms have in an ecosystem insight can be gained into the lives of more-than-humans. However the concept as is does not relate this to the experience of the user. **[medium]**

1.2 *The design promotes getting to know nonhumans beyond their names.*

The emphasis on organism roles rather than taxonomy is an important part in "getting to know" them. Several participants across the different tests expressed that they learned something about the world of the investigated organism. **[positive]**

1.3 *The design promotes systemic insight into the complexity of nature*

The map made with the observations from the pupils provides a complex, yet incomplete view on the system. In assessment with different educators and experts, concerns were raised about the complexity of such an activity for this target group. **[inconclusive]**

1.4 *The design prevents users from overlooking nature.*

The activity of going out and looking for organisms at different scales contributes to the skill of noticing. The participant from the pilot session mentioned that they learned where to find organisms. However, it is unclear if this contributes to noticing nature outside of the context of the activity. **[inconclusive]**

1.5 *The design does not promote an extractionist mindset.*

In looking for unexpected encounters there is a certain keenness. Although it was not directly evaluated, during one of the test sessions where I participated as fly on the wall it became apparent that this can turn into a competition and that children generally loose some

Keystone citizens perspective

consideration when engaged in competition. I can see how the web maker might mitigate this, but creating a competition around finding species may have adverse affects. **[inconclusive]**

2.1 *The design promotes the development of a biodiversity positive attitude.*

On several levels the N=ZIEN platform contributes to the development of a biodiversity positive attitude. By providing situated outdoor experiences with lasting effects through perspectives for action, meaningful knowledge can be gained about the environment of the user. **[positive]**

2.2 *The design relates knowledge to the local environment of its user.*

By having to find the very thing you are learning about in your neighbourhood the design aims to situate biology and ecology knowledge in the *umwelt* of the user. **[positive]**

2.3 *The design plays into the strengths of different learning environments.*

Although the design embraces the unique possibilities of taking classes outside and visiting the museum, it can still develop in connecting the experience with local initiatives and role models. **[medium]**

2.4 *The design promotes a proactive attitude towards the environment.*

While the design aims to provide perspective for action in the web maker tool, a concrete manifestation has yet to be designed and tested. **[inconclusive]**

Naturalis perspective

3.1 *The design is uniquely tied to Naturalis.*

The platform builds heavily on the resources (NatureAI, dierenzoeker), knowledge (Natuurwijzer) and experience (app development, ties with Klokhuis and Observation.org) Naturalis has. **[positive]**

3.2 *The design provides perspectives for action.*

The final lesson does provide perspectives for action, but this part of the concept has not yet been worked out completely. **[inconclusive]**

3.3 *The design can be connected to at least 2 of the 6 pack.*

The N=ZIEN platform is in line with the 6 pack, in particular *research driven, science know-how and activating* are present in the platform. **[positive]**

3.4 *The design connects people to the museum.*

Though the current curriculum is combined with a visit to the museum and one of the class programmes in the museum, the connection of the online platform with the museum could be explored more through and exhibition. [medium]

3.5 The design has a digital component.

The design consists for a large portion of a digital platform, though it should be investigated how this platform can be integrated more with the already existing websites that Naturalis has. [positive]

3.6 The design is connected to the larger digital ecosystem of Naturalis.

On the backend the design makes use of the data that is used for Dierenzoeker and will use the NatureAI api hosted by Naturalis. On the front-end backlinks to Natuurwijzer provide extra information for pupils to follow up on their interests. However, based on informal meetings with members from the education department, the concept could be integrated into the Naturalis app or have a stronger connection to Natuurwijzer and Natuurlab. [medium]

3.7 The design is appropriate for different (urban) environments.

During the field study it became apparent that the N=ZIEN platform has constraints on what urban environment is suitable. It showed that the schools need to have a relatively diverse green environment, that is publicly accessible and close to an area that they can alter. Furthermore, this environment should not pose any risks. During the evaluation session with observation.org a concern was raised that some schools do not allow activities outside of school grounds, making the N=ZIEN platform difficult or dull to carry out. [medium]

4.1 The design builds up step by step.

The lessons are built up in such a way that they introduce new elements every lesson, while complementing those of the previous lessons. Though, in the evaluation with the eductors from two biodiversity centers concerns were raised about the complexity, especially of the final lesson, so to answer this question the complete flow of lessons needs to be tested. [inconclusive]

4.2 The design conveys a neutral message (not positive not negative).

The design aims to let the children generate as much of the knowledge as possible, this allows them to form their own opinion on whether things are positive or negative. [positive]

4.3 The design acknowledges the agency children have.

On the one hand the design sees children as citizen scientists, emphasising the contribution they can make to science. On the other hand, during the fly on the wall sessions an idea about the is possible for children to do outside of class was investigated, however even at the conclusion of this thesis this notion feels incomplete. So although the platform provides a perspective for action in the map maker, it is unclear how well the acknowledgement of their agency carries over to everyday life. [medium]

4.4 The design combines physical activity with cognitive activity.

The platform invites pupils to discover by going around their neighbourhood and then applying what they have learned in class to what they have found. In this format I believe N=ZIEN has found a way to combine both cognitive and active learning. [positive]

4.5 The design is engaging to use.

Though difficult to answer for the platform as a whole, we can say that the identifier chat was a fun experience for children to do. Both the different institutes consulted for the concept evaluation as well as the participants in the user-test session at Naturalis appeared to find the identifier an interesting and engaging element. [positive]

All in all, the N=ZIEN platform appears to be a promising fit for the digital education product portfolio and as a product that encourages the development of a biodiversity positive attitude in children. Especially the identifier chat was well received by both institutes as well as the target audience. However, the design needs to be fleshed out more, to be able to assess it in its complete form and to be able to assess how the different design elements can complement each other.

Chapter conclusion

This focus of this chapter has been to ground and materialise insights gathered through research. As mentioned before, the more than human design discourse struggles with bringing its philosophy into practice. Through the conceptualisation of the N=ZIEN platform this chapter hopes to demonstrate how the more than human design discourse can find its way into design projects. This chapter aimed to investigate what the earlier found insights can mean for naturalis and how they can grow their digital product portfolio to develop a biodiversity positive attitude.

RQ4.A

How can the unique resources of Naturalis contribute to the design of (digital) artefacts for 10–12-year-olds in the Randstad to foster a biodiversity positive attitude?

Naturalis' unique resources and expertise offer strong potential for designing digital artefacts that foster biodiversity-positive attitudes among 10–12-year-olds in the Randstad. Their experience with applications like Soortsafari and Dierenzoeker.nl shows an ability to assess content and create engaging tools, even when taxonomy information alone is less compelling. As one of the largest biodiversity institutes in the Netherlands, Naturalis brings both credibility and collaborative reach, helping translate knowledge into captivating narratives that transform seemingly dull urban environments into places of discovery. Their reputation provides role models to inspire children and a narrative backbone for the artefacts. Finally, their reach enables the possibility that data generated by pupils could contribute to real research, gaining visibility through wider channels and fostering a sense of meaningful participation.

RQ4.B

How can we apply the keystone citizen framework to design product that complement and encourage the development of a biodiversity positive attitude?

Applying the Keystone Citizen framework provides the project with an overarching domain and a clear strategic direction, giving the products a strong reason for existence while aligning them with the broader goals of the institute. On a practical level, the framework's components guide the exploration of suitable niches by defining which manifestation of a biodiversity-positive attitude a product aims to foster, the means through which this is achieved, and the drivers that motivate sustained engagement. These elements translate into product-specific goals that offer both focus during design and concrete criteria for evaluation: the manifestation assesses overall contribution to the attitude, the means measure how well the activity engages users, and the drivers test assumptions about motivation and lasting impact. In this way, the framework functions as both a strategic compass and a practical tool for shaping and assessing products.



Figure 69. Ohara Koson's "peacocks on a flowering tree" exemplify the reverence artists around the globe hold for the natural world.

Evolution

Speculating about the future of this project

Limitations
Recommendations
Discussion
Reflection
Afterlife
Chapter conclusion

In this final chapter we investigate the future of this project. By highlighting the limitations and recommendations that followed from the concept evaluation, we can form an idea of what needs to be done to implement the N=ZIEN platform. Followed up by a mix of discussions and reflections we gain further insight into the considerations raised about the platform, context, stakeholders, system and my personal experience. Before truly ending the thesis, I have dedicated a paragraph to highlighting what lies in the future for the N=ZIEN platform and finally we will turn to our main research question.

MAIN RQ

How can digital educational products, designed from a more than human perspective, foster biodiversity positive attitudes to support transformational societal change?

Limitations

Since this thesis only encompasses 100 working days, there were two main limitations that added extra challenge to the project.

Conceptual nature

Although the N=ZIEN platform has been worked out to some extent, the overall experience and flow of the platform have only been conceptualised. Meaning that they are not worked out in a fidelity that allows for content assessment. This is mainly due to the time constraint of 100 graduation days, but also because great effort was put into formulating the problem statement in the form of the literature review, interviews and future vision sessions. Additionally, the platform consists of several elements (device, identifier, web maker) that also required design consideration. This meant that the different design components from the N=ZIEN platform have been developed to a surface level. This made it also difficult to assess them with the target audience as the different prototypes and sketches required some degree of introduction and imagination. To mitigate this more emphasis was put on the device and the identifier as they appear to have added value outside the N=ZIEN platform and could be used in different contexts as stand alone products. In a future project I would recommend applying focus earlier on in the project and setting appropriate goals for the degree to which the design components will be worked out

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Limited user-testing

Although parts of the N=ZIEN platform have been evaluated by the target audience, this was only in a limited form and may not have been representative. This came to be because of three reasons. There are no people from the target audience or people who have access to the target audience in the direct environment of me. The project was somewhat poorly timed with most schools either preparing for summer vacation or already being on summer vacation during this project's testing phase. The ethics approval was delayed somewhat, meaning that the recruitment process was delayed as well. For the project this means that the platform has mainly been evaluated on a conceptual level by different experts, but only limited on the interaction and experience level of the target audience. This, on top of the conceptual nature of the platform, makes it difficult to draw grounded conclusions on the success of the platform on answering the design goal. Throughout the project around 12 schools in the Randstad region have been contacted. However after discovering the difficulty of finding a willing party, the focus has been shifted to also recruit adults with a connection to the topic and speculate about the experience of the children. The best way to prevent this would be to find a pilot party from the very beginning.

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Recommendations

Throughout the development of the N=ZIEN platform an array of design requirements were collected. While some of these requirements are just one iteration away from implementation in the N=ZIEN platform, others have a more fundamental implication. Based on these requirements and the evaluation, six recommendations for the development of the N=ZIEN platform can be made.

Institutional integration

Though created in collaboration with the education department, the solitary nature of a thesis project has led to N=ZIEN being developed in somewhat of a vacuum. Attempts to mitigate this have been made by updating employees and reaching out to different departments, but ultimately it is difficult to be up to date for everything that plays in the organisation. Therefore, it serves to run this project in a team. On top of that I would also recommend to investigate the different design components separately. As throughout the project different departments have expressed interest in different components for different goals. Such as the biodiversity garden, biodiversity exhibition and Naturalis app. Perceiving the different elements as components that may be used interchangeably between products may enlarge the reach of the underlying principles found to be relevant for the development of a biodiversity positive attitude.

Adoption

To increase the chances of adoption for schools, the SLO learning goals were considered. However, these were subjected to a non-expert interpretation of the goals. Therefore, I would recommend to shape the lessons further to reflect the SLO learning goals.

Additionally, during a conversation with someone from the marketing department it was mentioned that the product needs to be presentable and clear. Therefore, making a brochure specifically for the N=ZIEN platform and its components may help to spread awareness of the product.

Interaction development

During the user-tests it was found that the identifier relies heavily on reading. While the other elements of the platform were conceptualised to be interactive and highly visual, it serves to point out that the interaction with the platform should be thought out more and tested with the target audience. Here I recommend creating a sample lesson together with the relevant experts and a mock-up website to mimic the complete experience.

Scientific scoping

During the thesis the scientific value of the observations and map were explored. Here I believe that while the true scientific value may be limited, for the pupils this is where science is made. Therefore, I would encourage Naturalis to investigate how they can enhance this experience and emphasise that the users are generating scientific knowledge through their actions. To do this Naturalis needs to scope how the data collected by the pupils can be interpreted in a scientific way, while still acknowledging the limitations of the collected data.

Stakeholder collaboration

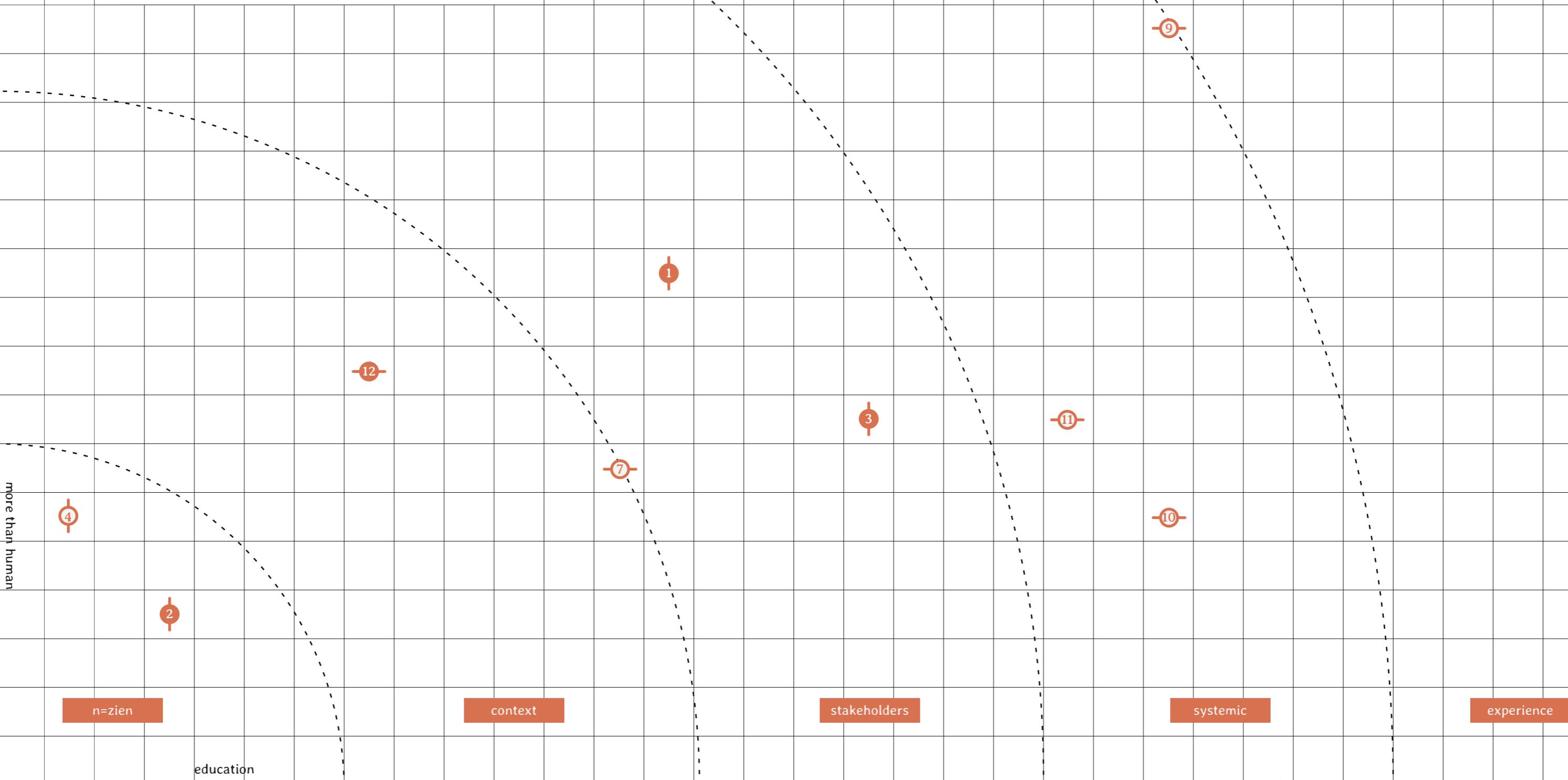
As mentioned before a limitation of this project was the access to the target audience. Therefore, I would recommend finding a school, class or institute that can provide a pilot group of pupils to provide continuous feedback on the development of the platform as a whole and the different design components.

Goal development

Finally, I would recommend for Naturalis to formulate what we want children to take away from the experience of interacting with the N=ZIEN platform exactly. For the thesis this has stayed rather conceptual, but formulating clear takeways may give the platform more focus and clear guidelines on what perspectives for action should be incorporated. Here I would also recommend to introduce these perspectives for action throughout the lessons rather than just at the final lesson.

Discussion and Reflection

In the introduction seven areas of contribution are introduced. In addition to these areas four areas of reflection were found throughout the project. The figure below shows how the different discussion and reflection paragraphs relate to the abstraction levels found throughout the project



Biodiversity positive attitude

One of the main contributions of this thesis is the Keystone Citizen framework and the corresponding parameters that aid in formulating a design statement. The framework has functioned as both the foundation for ideation and concept development as well as forming the basis for evaluation of the design. This framework is the manifestation of the thesis goal to create a definition for the biodiversity positive attitude. Although a complete framework is presented, some aspects have been researched to a greater extent than others. Since the education department expressed a preference for developing nature connection and participation in activities for this specific project, these areas have been prioritised. Despite this, I believe the Keystone Citizen framework functions well as a starting point for formulating design ambitions and fine tuning the design impact.

Exploring avenues

With the Keystone Citizen framework as a starting point this thesis has also shown through an exploration of different avenues that a biodiversity positive attitude can be supported in an array of ways. This suggests that depending on the specific target audience, context, goals and constellation of users the design goal may change while still contributing to the overall goal of supporting a biodiversity positive attitude. This can be tied to the ambition to investigate numerous

ideas in order to better grasp the most effective way for Naturalis to engage their audience in developing this attitude. The trade-off here however, is that the breadth of this project left little time for developing the most promising direction for this scenario, making it challenging to evaluate the framework and design. Therefore, for future projects at Naturalis I encourage them to learn from these explorations and steer clear from developing concepts in parallel if there is a tight deadline. While for the design discourse I would recommend to either scope the project as exploratory or as specialised and adjust the planning accordingly.

Enhancing the digital portfolio

The constraint of contributing to the digital product portfolio shed light on how digital and analog products are experienced differently. Especially digital products were considered intrusive in scenarios like sharing opinions and sensing the natural world. This indicates that certain parts of a biodiversity positive attitude are best accomplished through nondigital products or that the "digitalness" of these products need to be hidden to be comfortable. Tied to Naturalis' overarching and thesis inducing question of how the digital portfolio can be enhanced to complement the biodiversity positive attitude this insight shows the importance of designing products considerately and with acknowledgement of their influence on people's lives. Having such a

User-centered design and more than human design

A core contribution to the design discourse is deeper insight in the boundary conditions of marrying user centered and more than human design. Since the project maintained a conceptual state, it was difficult to engage in the front-end user research often used in user centered design. Reflecting on the process I found that the activities I undertook resembled more a research through design approach than a user centered approach. Based on this we can conclude that user-centered design becomes relevant only later in the process when the manifestation and the impact of the design are more apparent. So if we return to the ambition of this thesis to provide a case study for a combination of user centered and more than human design I believe this project may not be a good example, but we can draw a lesson from it. Focussing on providing such a case study may have blinded me for other approaches, which made evaluation especially difficult. For other designers I would recommend that they consider the level of abstraction of their project before selecting an approach.

Education and more than human

6

There is a surprising amount of overlap between the education philosophy of constructionism and the more than human design perspective. While constructionism is human centered by prioritising learner agency, it does open up the idea that learning and thinking is situated and mediated by technology. This suggests that there is potential for cross pollination between these two disciplines. Although this insight is not tied to a specific desired contribution, it seems like a valuable thing to point out. Especially since there are only a handful of scholars who have touched upon the topic and often not directly related to design as a discipline but rather design as a means of learning (Neyrat, 2021; Kynigos, 2015; Kafai & Resnick, 1996). Unfortunately the theory of constructionism is something that I came across late in the process of this thesis and therefore have not been able to integrate fully into the project. However, I have observed that at my university more than human design has become more popular as a research topic, especially in combination with education. Therefore, I would recommend researchers to do a deep dive in constructionism theory before shaping the flow of the educational tools they might develop.

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Industry bubble

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Throughout the project I was met with little resistance regarding the underlying theories. Most of the critiques from the different experts raised concerns about the fit of the N=ZIEN platform and manifestation as means to encourage a biodiversity positive attitude. Even though the breadth of experts have given diverse perspectives on what the biodiversity positive attitude is and how to improve the N=ZIEN platform, I wonder whether these thoughts are those of an industry bubble. Therefore, it would be interesting to incorporate the views of people with vastly different perspectives or backgrounds. On the other hand I wonder if it is wrong to stay in this assumed bubble since it did manage to find footing in an established organisation such as Naturalis and incorporating more perspectives might create a situation where the design aims to compromise between two many perspectives. To overcome this it could be meaningful for similar projects to talk to some antagonising figures or institutes to find out if there is common ground and to demarcate the project if there is not.

8

Romanticised view

Most literature regarding nature education and ecological literacy encourage deep wonder for nature. In some cases this can be interpreted as a sort of marvel or majestiness. While on the other side the Michael Crichton books I have been reading during my thesis promote the idea of a vicious nature. I personally believe the truth is somewhere in between, but I have also noticed that I actually do not possess the knowledge to make a grounded argument. While taking a stance

here does inform what we teach our children about the natural world. Having unknowingly projected my own perspectives on the project I can see how the N=ZIEN platform can be seen as a romanticised idea of humans partaking in the natural world as benevolent stewards. Something that I did not intend to do necessarily. To prevent a certain unfounded perspective from sneaking into a project, I would ideally recommend working with experts in a participatory setting while drafting placeholder content or thinking about systems.

9

The complexity of truth

During the project I have interacted with different experts and participants. In these interactions the truth became not as universal as one might expect. People might believe things because of different reasons and may forget that it was a journey to get to the conclusion they have. I would agree that objective truths, those with scientific grounding, should be considered a good basis for drawing conclusions and formulating opinions. However after examining more than human literature I have also come to see the truth is a subjective thing as well. As political bodies, first hand experiences and prejudices can skewer our perspectives and reality. Therefore I feel a need to acknowledge these alternative perspectives and allow people to

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come to their own conclusions. For some stakeholders this was easier to accept than others, which makes general collaboration a bit more difficult as we'll see in the reflection on platforms. When we look at it from a constructionism perspective it also makes sense to empower the users of the N=ZIEN platform to construct their own knowledge. This also embraces the subjective views and prejudices students might have as part of the process. Therefore I think that ultimately it is up to designers to address this complexity. To allow for these different forms of truth to coexist, but also to provide the means for all to adjust their views of the truth based on (first hand) scientific discovery.

Paradoxes of platforms

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During the thesis I came across the book *Politics of Platformization* which criticizes the centralized control often seen on platforms while acknowledging its decentralisation of access to content (The Institute of Network Cultures, 2023). Although they mainly talk about large platforms such as Facebook and Google and their role in (re)shaping collective behaviour, I could not help but think of my own endeavors of reshaping collective behaviour through the N=ZIEN platform. This drove me into a rabbit hole of considering the tensions between transparency, truth and goals. Where the undertone of care in the book made me realise that platforms in the more than human perspective have an obligation to leave room for interpretation and in the philosophy

of constructionism should leave room for active participation in "science in the making". Interestingly, they suggest that platforms should emphasize change in systemic structure rather than individual behaviour. Providing a perpendicular view to what this thesis sets out to do. This makes it difficult for me to provide a conclusive answer on how Naturalis should shape such a platform, but I do believe that the N=ZIEN platform does not seek to control, but rather inspire alternative ways of being.

Nudging for change

-11-

For this project a more than human design perspective has been adopted. However by questioning an anthropocentric world view it has also become intrinsically connected to designing for behavioural change. Also in this thesis such an ambition has been set. Although this thesis has not drawn extensively from the body of literature regarding design for behavioural change, in hindsight it has followed a similar path. For me, using design principles to facilitate a biodiversity positive attitude seems desirable. However, I can imagine that individuals with a different background might think differently about it. Abstracting the design goal leaves us with nudging children to become a certain kind of person. Which depending on the context seems like a good thing or a bad thing. This made me realise the importance of transparency in the communication about the goals behind the design and the importance of leaving room for other viewpoints. On the other hand I think this might over estimate the impact of such a platform. Since the N=ZIEN

platform is still subjected to a free market where schools and institutes select their own nature education materials, competition may prevent the platform from being too radical in its nudging. Therefore, I believe that if the intentions of the platform and Naturalis are transparent and there are other tools out there that provide a counter message it leaves enough room for schools to make up their own minds. On top of it, I would also encourage designers to clearly establish what exactly they want to achieve and whether this is within ethical norms.

Target audience

-12-

Early on the consulted literature pointed out that children ages 10-12 are the ideal target audience for developing a biodiversity positive attitude. However when trying to engage with this audience I discovered that it is quite difficult to reach them and that there are quite some programmes for them already. This made me rethink whether the selection of this target audience was the right choice for this particular project. Because, although the impact may seem to be the largest with this group on paper, in practice there are other factors to consider than susceptibility. For this particular project I think the target audience is still a suitable pick. Mainly because of the theoretical grounding of the Keystone Citizen framework and the focus on becoming through education. However, if the framework was used in a different context to develop an educational tool I would encourage the designers to consider other target audiences as well.



Figure 70. over the course of the following months this QR code will be added to

Afterlife

Beyond what Naturalis and the design discourse pick up from this thesis, there are activities that are within my reach to engage with to enlarge the impact. There are three areas of impact that I will address: At Naturalis, at the TU Delft, the outside world.

Even though people from different departments within Naturalis have been contacted, with more than 300 employees, not everyone is aware of this project. Since it has a strategic undertone and finds footing in several ambitions a meeting has been planned with the public engagement management team to inspire the strategic course for the public engagement silo and to see where the insights of this project might be used elsewhere.

During the project different TU Delft educators have been consulted. Alongside an invitation to the graduation presentation a small booklet containing the design research insights will be shared with them.

Finally, the project has been selected for the E-Magazine for the Dutch Design Week 2025 under the theme Thriving Planet. Here the design contributions of this thesis will be laid out for web visitors. Additionally the project has been selected for Kennis Maken: National Citizen Science expo 2025. During this event the N=ZIEN platform will be presented to a general audience as a case study for how citizen science contributes to the development of keystone citizens on several levels.

Chapter conclusions

Throughout this project we have approached the intersection of biodiversity positive behaviour, education, digital tools and more than human design from different angles and abstraction levels. We started off with building an understanding of what we are dealing with through literature research and expert consultations. In the second part we adopted a forward looking perspective and asked ourselves how we ideally would like to see things in order to set the stage for the third part. Here we investigated how we can bring these insights to life, ground them in society and situate them in the context of this project brief by conceptualising the N=ZIEN platform and evaluating the different design components. Now we can look at what this means for the main research question and how it informs what happens next.

MAIN RQ

How can digital educational products, designed from a more than human perspective, foster biodiversity positive attitudes to support transformational societal change?

Education influences what people become and thus can play an instrumental role in facilitating transformational societal change. In the design of educational products we can acknowledge the influence they may have on the development of people. Here, we need to be considerate of the forces that drive society today and what forces may influence the shaping of the society of tomorrow. By facilitating reflection through conversation and past experiences, deeper understanding through learning and experiencing, and exploration through engagement with the world around us educational products can create circumstances for the transformative learning environments necessary for societal change. Through incorporating a narrative that breaks the barrier between nature and culture these products can further contribute to the idea of a shared world, instilling care and participation. Allowing for products, digital and analog, which are informed by these factors to situate themselves in the environments of people, making them meaningful and desirable.

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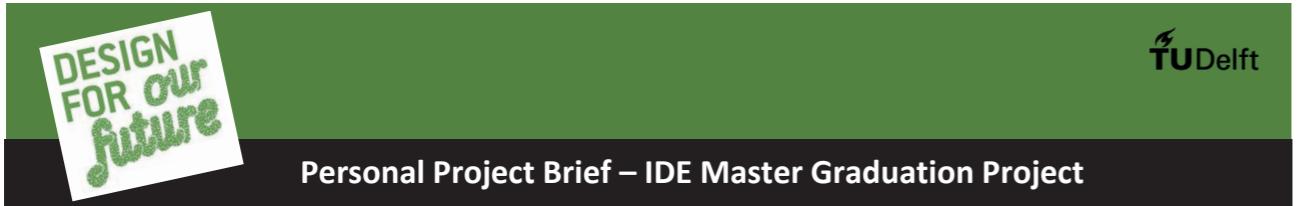
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Appendix: Design brief



Name student Sander Aalbers Student number 4673077

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT

Complete all fields, keep information clear, specific and concise

Biodiversity positive futures: bridging the gap between expert, more-than-human and user
Project title

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

The past decades have shed light on the urgency to reconsider human activity with regards to the environmental impact. Several adverse effects that destabilise ecological resilience have been attributed to polluting industries and practices, one of those effects is the decline of biodiversity globally. The root cause of the continuation of these practices is complicated and comes in multitudes across all societal levels, ranging from consumer behaviour to governmental legislation. However considering the biodiversity crisis a portion can be ascribed to a lack of tools, resources and alternatives for individuals to change their behaviour favourably. This project therefore, takes a bottom up approach and aims to provide a means for individuals to sustain a biodiversity positive attitude. This project zooms in on the relationship of individual humans with their more than human neighbours. In collaboration with the education department of Naturalis Biodiversity Center, this relationship is unpacked and imagined through (digital) educational products and how those can contribute to and maintain a biodiversity positive attitude. Herein the project investigates how these products can play a transformative role in behavioural change with regards to attitude. The project focuses on the Dutch context and how products may develop to suit the future Dutch context.

While the driver of this change can be considered an act of self preservation, to truly maintain ecological resilience we have to decenter society and also consider the needs of more than human actors that are involved. Therefore, the project will have to strike a balance between the often juxtaposed needs of society (e.g. housing, infrastructure) and the natural world (e.g. habitat, sustenances).

The main challenge in this project lies in making a biodiversity positive attitude attractive for a large audience alongside balancing the more than human needs of different stakeholders. However, contemporary technology may provide a unique opportunity in mediating these needs.

➔ space available for images / figures on next page

introduction (continued): space for images

click to add picture

image / figure 1 Core stakeholders with main driver

image / figure 2 Solution space and problem scope

**Personal Project Brief – IDE Master Graduation Project****Problem Definition**

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice. (max 200 words)

At the core of this project there are several problematic elements. From the humans perspective the most fundamental being the lack of a unified definition for a biodiversity positive attitude and therefore also the lack of accessible knowledge among non-experts on how they can adopt such an attitude. On top of that, decentering the needs of humans requires a holistic point of view from humans, but also concrete needs from the more than human world. Making this apparent and appealing for humans, who tend to have a privileged position in this relation, makes this design project challenging. Furthermore, from a designing perspective there appears to be a gap between more than human design theory and practical application, with limited examples of successful integration into society. Therefore it will be difficult for this project to draw from successful alternatives. Additionally from the perspective of pro-biodiversity institutes, there is the issue of integrating and synergising with existing products and services. This leaves us with a primary tension field in which to operate: How can we manifest desirable education products while also decentering the human in promoting a consistent preferable biodiversity positive attitude. As a designer my unique contribution is creating common ground between the stakeholders (experts, non-experts, more than humans) and making this information apparent, while also designing interventions that are appropriate for the context and the needs of those stakeholders.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Create an attractive (digital) product that facilitates the interspecies dialogue in order for young Dutch individuals to realise a biodiverse future by becoming an advocate for their more than human neighbours.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

The activities of this thesis project can be roughly summarised into three phases. The first phase works towards an idealistic future vision for biodiversity positive attitudes. This is achieved by collecting knowledge on different proverbial building blocks through desk research and expert interviews. With these building blocks in place the project can be scoped down and several solution spaces will be synthesised. Based on these solution spaces, generative sessions with potential users, practitioners and experts will be held to substantiate desirable futures. In the second phase these future visions will be given more substance through ideation sessions which will be done individually as well as with stakeholders. Additionally the product educational portfolio of Naturalis will be analysed to identify overlap. Based on which several concepts will emerge. These concepts will be built on assumptions which will be evaluated through interventions in the form of prototypes and user testing. In the final phase insights from these testing sessions will be compiled into design principles. Based on these principles an iteration will be initiated on promising concepts to further flesh them out. Finally the project will provide one or more promising solutions for Naturalis to provide a tool that supports a biodiversity positive attitude alongside a list of recommendations in the form of design principles.

Project planning and key moments

To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a kick-off meeting, mid-term evaluation meeting, green light meeting and graduation ceremony. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).

Make sure to attach the full plan to this project brief. The four key moment dates must be filled in below

Kick off meeting 13 Feb 2025

Mid-term evaluation 24 Apr 2025

Green light meeting 03 Jul 2025

Graduation ceremony 7 Aug 2025

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	<input type="checkbox"/>
For how many project weeks	25
Number of project days per week	4

Comments:
I will work one day in the week.

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five. (200 words max)

In the future I see myself working as a part time designer of IoT-like products, combining data, physical products and digital implementations into context appropriate solutions. However, in my spare time I would like to make an impact by applying my designerly skills to innovate rewilding practices through my own initiatives and participating in innovation challenges.

For this final university project I wanted to do a project that would set me up for both. I believe Naturalis provided an interesting case to develop both, while also providing a unique insight into what it's like to work in an organisation such as Naturalis. During this project there are three main skills that I aim to develop and show:

1. Tackling complex multidisciplinary problems through gathering relevant data, synthesising insights and creating solution spaces appropriate to the context.
2. Manifesting theories, ideas and concepts in the real world through the fabrication of (digital) prototypes and validating core assumptions through user testing.
3. Moving between disciplines and connecting people, theories and methodologies to cross pollinate and create a sum that's larger than its components.

Additionally, their commitment to an harmonious existence with the natural world not only resonates with my personal beliefs, but also provides an opportunity to explore what I can contribute to innovating the field and it may provide me with a network of like minded people.

