Nature connectedness through living artefacts: A case study for Urban Reef

Author: Dawn Verkerk
MSc Thesis Integrated Product Design
Chair: Prof. Dr Elvin Karana
Supervisor TU Delft: Dr Rebecca Price
Supervisor Urban Reef: Dr. Ir. Pierre Oskam
Date: 7th of June 2023

URBAN REEF

Abstract

Cities have witnessed the disappearance of natural habitats, putting biodiversity at risk and leaving citizens with a diminished connection to nature. Establishing a strong human-nature connection is crucial for sustainable transformations in society, influencing sustainable norms, values, and policy decisions.

Urban Reef, a company specializing in 3D-printed ceramic Reefs, offers a solution to improve urban biodiversity by hosting various living species. These Reefs are considered “living artefacts” as they evolve over time with the colonization of natural species. However, little research has been conducted on the social dimension of such living artefacts and how they can positively impact human users and their connection to nature. To address this knowledge gap, this research aimed to explore how Living Artefacts, like Urban Reef’s Reefs, can help urban citizens feel more connected to nature. The project employed a combination of Research through Design and Co-creative Design approaches to answer this question.

The research commenced with a user study conducted during a family science day, utilizing interactive posters, observations, and the creation of clay seed combs. The results, along with a literature review, revealed a limited connection to and awareness of nature within urban environments. However, the study also demonstrated the potential of engaging with Reefs to enhance nature connectedness. In the subsequent phase, a citizen science study involving five participants caring for and monitoring a Reef showcased improvements in human-nature connectedness. Participants experienced a shift in their perception of nature and developed meaningful bonds with the Reef.

Drawing upon the citizen science findings and an extensive literature review, a comprehensive collection of design guideline cards for living artefact designers was created. The card set encompasses seven pathways to increase nature connectedness through living artefacts: Living Aesthetics, Interactions, Affective Response, Habitabilities, Care & Compassion, Views of Nature, and Ecological Knowledge. These cards serve as a valuable resource for designers, providing diverse approaches to adapt ideas, designs, and prototypes to create living artefacts that foster a stronger connection between urban citizens and the natural environment.

Moreover, the cards feature concrete examples of Living Artefacts, offering tangible illustrations to support and inspire designers in their creative process.

Additionally, three concept designs were developed by applying the design cards to Urban Reef’s existing Reefs, serving as illustrative examples of potential outcomes achievable through the utilization of the design guidelines. The thesis project concluded with a user evaluation of the design concepts, followed by recommendations for the future development of Urban Reef. These recommendations aim to guide the market introduction of Reefs in the coming years. The thesis project also provides additional recommendations for further refining the design guidelines.

In summary, this research project highlights the importance of fostering a human-nature connection in urban environments. Through the exploration of Living Artefacts, such as Urban Reef’s Reefs, and the development of design guideline cards, this project offers insights and tools for designers to create living artefacts that enhance nature connectedness among urban citizens.

A1. Living Aesthethics

- **Does the artefact contain natural characteristics (shapes & colors etc)?**
- **Is it an artistic artefact?**
- **Is it a wearable object?**

A2. Living Aesthethics

- **Does the artefact look like it is alive and living?**
- **How does the artifact change and evolve over time?**
- **How is the livingness expressed in the physical attributes to see (feel, smell, hear or taste)?**

Algae graphs
Lia Giraud & Claude Yéprémian, 2014

Example Living Aesthethics

A living image is made by projecting a negative image on to a Petri dish containing a microalgae culture, and then displayed at an exhibiton. The images will continue to live and evolve in the face of the hostile conditions of the exhibition: degradation, contamination, interventions by the viewer, etc.

Relevant pathways

Table of Contents

URBAN REEF

1. Introduction

This section will introduce the project's background, the company of Urban Reef as well as the thesis scope focusing on the social domain of living artefacts.

Background

Due to an increasing global population and urbanisation, cities around the world are exceedingly dense with many concrete structures. Many forests are being taken down and more houses are built every day. Space for natural habitats has disappeared from cities and biodiversity is at risk (Radic and Gavrilovic, 2020). The disappearance of urban green and biodiversity has resulted in the creation of the urban heat island effect and inadequate ecologically resilient cities (Mohajerani, Bakaric et al., 2018). Furthermore, as a result of flora and fauna disappearing from the city it has been shown that citizens have little to no connection to nature (Graham, 2017). In our modern day society, many of us do not feel as part of nature. Likewise, many 'laypeople' are not aware of the urban nature that is around them and they have little knowledge about biodiversity (Hooykaas, Schilthuizen et al., 2020).

In this modern society the world is focused on humans. Humans have literally taken over the world. Most of our landscapes consist of urban environments which are focussed on habitats for humans and the 'non-human life' that is there has to fight with our leftover scraps to survive(Radic and Gavrilovic, 2020). If there are plants and animals in the city it is mostly for the benefit of people: for our entertainment as pets or in zoos, for shade and decreasing heat or for recreation in parks. The company of Urban Reef thought it was time for a change, they believe that the urban environment can become a habitat for not only humans and a few selected species of flora and fauna but a space where humans can live together with wildlife amongst them(Urban-Reef, 2023).

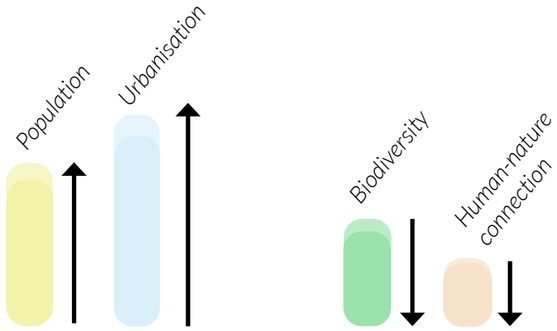


Figure 1. Representation of changes in Society

Urban reef

In order to go create a world where all life forms live harmoniously together in urban areas the company Urban Reef has designed a bio-receptive artefact that they call 'Reefs'. Reefs are defined as "porous, labyrinthic, water-retentive structures that can host a spectrum of buffers and micro-climates.". These urban reefs are currently made of 3d printed bio-receptive ceramics and different organisms can inhabit these reefs. The company of Urban Reef is a young start-up that is still full in development. A lot of research is being done towards improving the design and use of the reefs they are currently focussing on 4 areas: Material-, bio receptivity-, design- and utopia research. Additionally, the idea is that in the future people can engage more actively with the reef not only through senses but with the use of sensors and feedback in an app(Urban-Reef, 2023).

Currently, Urban Reef is located in Rotterdam and also in contact with amongst others the municipality of Rotterdam. They are mostly funded by subsidies from different funds. These urban reefs, increase the local biodiversity, purify the air and bring down local temperatures. Therefore many municipalities are interested in adding these bio-receptive artefacts to their cities as they will help them reach their climate goals. Lastly Urban Reef are also researching other opportunities for one of the reefs to be put on the consumer market in the long term. (Gemeente-Rotterdam, 2023, Urban-Reef, 2023)

Figure 2. Urban Reefs with founders (Urban Reef, 2023)

Figure 3. 3D Printing Process of Reef (Urban Reef, 2023)

Living artefacts & the social domain

As defined by Karana et al. "When organisms are still alive in the material outcome of the design process and their envisaged usage is extended to the use time, livingness becomes a persistent material quality in design" then the outcome is a 'living artefact'(, 2020). The reefs from Urban Reef are an example of a design that can become a living artefacts as they have the potential to foster and become one with different living organisms and therefore take on different functions for other species over the span of their use time. In this case the main end user currently is however not humans but other non-human species in the urban environment.
Here the question poses if these reefs should be 'used' by humans as well as other species, and then what the main function will be of the reefs for humans. And on the other side, what can humans 'add' to the reefs to help them thrive in the local eco-system?

As there is currently adequate research into the ecological benefit of these bio-receptive living artefacts little research is done into the social dimension of such living artefacts (Karana, Barati et al., 2020). These artefacts are placed in several urban locations where they will be perceived by local citizens and visitors. It may even be that in the future people can buy an urban reef for in their garden or attach a reef to their rain pipe(Urban-Reef, 2023).

The living artefacts of urban reef have the potential to help in healing our urban ecosystems and give space for a richer biodiversity of species to live in the city together with humans. However, in order for these artefacts to be adapted in the society and to make space for more different species in the city it is still humans who have to accept the use of reefs in their habitat. Therefore, the question poses what the current social dimension of these living artefacts reefs are and how they can be adapted to increase the human-nature connection?

"When organisms are still alive in the material outcome of the design process and their envisaged usage is extended to the use time, livingness becomes a persistent material quality in design" then the outcome is a 'living artefact'(Karana et al, 2020).

2. Project Questions

The main goal of this project is to answer the following main research question:

How can Living Artefacts, like the 'Reefs' from Urban Reef, help urban citizens feel more connected with nature?

Scope

The research project selected urban citizens as the target group, primarily because they constitute the main audience of Urban Reef, and studies indicate that urban citizens generally have a lesser connection to nature compared to their rural counterparts (Bashan, Colléony et al., 2021). Additionally, the focus was specifically placed on Dutch urban citizens, particularly those residing in or near Delft, as it was a feasible choice considering my resources as a graduation student conducting the research.

End result

After addressing the research questions that are mentioned above the results will be summarised in one concept design (alterations to the) reef and design guidelines on how to adapt living artefacts to increase the human nature connection in cities . This will be the end result of the thesis project.

The sub research question s are separated between the current situation and the desired future situation. The knowledge gaps that need to be addressed are categorized according to the three principles of living artefacts: (A)Living Aesthetics, (B) Mutualistic Care and (C) Habitabilities (Karana, Barati et al., 2020).

1. What is the current (average) connection between humans and nature within our urban society and what is the role of living artefacts in this connection?

2. What kind of relationship do urban citizens currently have with the Reefs?

2. A: Living aesthetics: How do urban citizens perceive and experience the Reef?

2.B: Mutualistic care: How do urban citizens currently interact with the Reef and the environment?

2.C: Habitabilities:What is the current (second) habitat of the reefs and how do urban citizens play a part in this?

3. What kind of relationship should citizens have with the Reefs in order to feel more connected to nature? What changes are needed to help craft this relationship?

3. A: Living aesthetics: How should urban citizens perceive and experience the Reef?

3.B: Mutualistic care: How should urban citizens interact with the Reef and the Environment?

3. C: Habitabilities: What should be the(second) habitat of the reefs and how should urban citizens play a part in this?

3. Project Approach

In order to execute this project, I worked on a total of five phases: 1) Context Research, 2) Research & Design direction, 3) Co-creative research & ideation, 4) Design development & Evaluation, and 5) Documentation. Within all of these phases, multiple iterations were completed on designs, as well as multiple rounds of literature research.

1. Context Research

- Literature research into biodiversity, bio-receptivity and social factors concerning living artefacts and human- nature connection.
- Interview experts from urban reef, research the reefs more.
- First exploration of social context reef.

2. Research & Design direction

- The design brief will be redefined after gathering insights from context research.
- From the insights of the context research phase a new research & design direction will be chosen.
- A new research will be thought out in order to gain more valuable in depth insight for the final design.

3. Co-creative research & ideation

- New co-creative research to research new found design direction.
- Ideation together with users.
- Individual ideation of guidelines/ concepts.

4. Design Development & Evaluation

- Make a first iteration of design guidelines.
- Re-iterate on design guidelines through discussing with designers
- Develop some concept design alterations of the Reefs with the guidelines.
- Evaluate desirability, viability and feasibility of concept designs through user feedback.

5. Documentation

- Documenting design and the process in a report.
- Making a poster that shows the end result in context.

Throughout the project, I have applied several design methods, with the main methods being 'Research through Design' and 'Co-creative Design'. These methods have been chosen due to their potential to uncover valuable insights and surprising possibilities (Godin, 2014) (Sanders and Stappers, 2008). Furthermore, they actively involve potential buyers for the Reefs that Urban Reef intends to introduce to the market in the near future.

Research through Design

The 'Research through Design' approach involves the creation and exploration of design interventions or artefacts, in order to research a hypothesis. In contrast to many other research methods, this method does not solely rely on scientific methods. Instead it uses the iterative and reflective essence of the design process to investigate research questions and generate further design ideas. Research through Design is usually applied to projects which ask for an explorative style of working and aim to create design guidelines or a framework (Godin, 2014). Therefore this approach has been applied to my Thesis Project several times as can be seen in later Chapters.

Co-creative Design

The co-creative design approach entails active involvement and collaboration with different stakeholders, including users, experts, and other relevant parties, within the design process. The outcome of the design process is created together with these stakeholders, rather than solely by the designer. This method is used to create richer and more meaningful designs that can increase user satisfaction and usability. Throughout this approach, various methods were applied in this project, ranging from brainstorming, interviews, workshops, to co-design sessions and citizen science (Sanders and Stappers, 2008).

4. The Social Domain of Living Artefacts: Reefs

In this Chapter a more deeper understanding of the social domain of urban living artefact is presented that resulted from literature research. This Chapter will start with a definition of certain concepts that are relevant to the research domain. And it will close of with a conclusion on the current estimated role of living artefacts in our modern society.

Living artefacts

According to Karana et al. (2020), the term “living artifact” in the realm of sustainable design refers to an object that incorporates a living element, establishing a symbiotic relationship between the living component and its human user(s). In this context, the relationship goes beyond

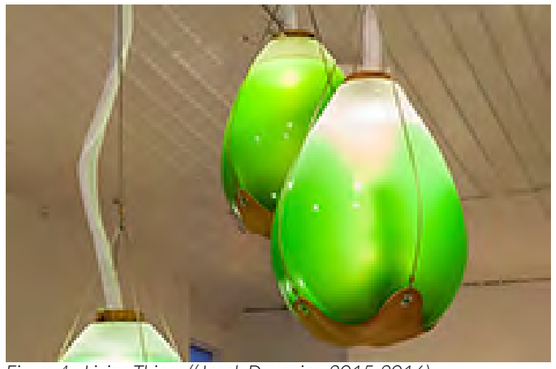


Figure 4. Living Things ((Jacob Douenias, 2015-2016)

mere utilization; it encompasses a caretaking dynamic where humans become not only users but also caretakers or even companions.

Living artifacts are intentionally designed to evolve and adapt over time, considering user input and responding to changes in the social and environmental context. The objective is often to cultivate a dynamic relationship between individuals and their surroundings, encouraging sustainable behaviours and practices over the long term. By continually adjusting through multiple usage cycles, these artifacts can have a lasting impact and foster resilience beyond their immediate function or aesthetic appeal. An illustrative example of a living artifact is furniture infused with algae and plants that generate light, as depicted in Figure 4 and 5 .

A majority of people are not familiar with bio design and living artefacts, which are relatively new concepts in their awareness. Consequently, individuals may exhibit hesitation or reluctance to engage with these living artefacts as they can be found intimidating or futuristic. However, it is noteworthy that these artefacts possess an inherent captivating quality, often evoking a sense of wonder and fascination among potential users. Despite this intrigue, many users still harbour doubts regarding the purpose and necessity of incorporating these living artefacts into their lives (van den Broek, 2022). As a result, the current acceptance and integration of these living artefacts into daily life remains relatively low.

In order to address and improve user acceptance of these living artefacts, van den Broek (2022) conducted a comprehensive literature review. The review aimed to explore the underlying motivations and desires that drive individuals to coexist with other living beings. Through this investigation, six key concepts were identified: hedonic benefits such as biophilia, care, and meaning, as well as utilitarian benefits including the performance of tasks, utilization as a source of material, and the provision of knowledge and skill. These concepts shed light on the various ways in which living artefacts can bring value and enhance users’ lives. Based on these findings, the researchers proposed eight guidelines to support and promote user acceptance of living artefacts(van den Broek, 2022).

These guidelines offer practical recommendations that can be employed during the design process of this project. They serve as valuable resources, informing the development of my own design guidelines, and aiding in the creation of living artefacts that are more appealing, engaging, and readily embraced by users. By leveraging these guidelines, we can strive to increase user acceptance and foster a greater appreciation for the benefits and possibilities that living artefacts can bring to our daily lives.

Figure 5. plant with light (Living light lamp, 2023)

Urban Reefs

Urban Reef is a company that specializes in creating artificial reefs in urban areas to increase biodiversity and provide habitats for various species of flora and fauna, including birds, insects, and plants. These reefs are 3D printed from recycled ceramics amongst other materials and designed to replicate the natural features of coral reefs, providing a welcoming environment for urban wildlife. The porous structure of the reefs enables them to become bioreceptive and support the growth and development of living organisms on the surface of the reef sculptures, given optimal environmental conditions. Urban Reef adopts a “more-than-human design approach” to address the loss of natural habitats and change the perspective that cities are only for human habitats. Their goal is to foster the regeneration of urban ecosystems and create harmonious urban environments that support both humans and wildlife(Urban-Reef, 2023).

Figure 6. Zoom in of Reef under stream of water (Urban Reef, 2023)

Figure 7. Urban Design Vision of Urban Reef (Urban Reef, 2023)

Urban Design Vision Urban reef

Urban Design is the process of creating functional, sustainable, and aesthetically pleasing physical structures and forms in urban environments such as cities and towns. It involves designing public spaces, transportation systems, buildings, and infrastructure to meet the needs of the people who live, work, and play there (Urban-Design-Group, 2023). Urban Reef aims to contribute to local urban design by creating environments that are suiTable not only for humans but also for wild plant and animal species (Urban-Reef 2023). Currently, Urban Reef’s reefs are standalone sculptures. However, the goal is that they will ultimately be integrated into buildings, urban furniture, and more, becoming part of the streetscape. These reefs will become a topic of discussion and initiate interactions between neighbours, promoting effective urban design that enhances the quality of life for humans as well as other natural residents, creating social interaction, and increases local biodiversity.

Bioreceptivity

In the field of sustainable building design, the term bioreceptivity is used to describe the ability of a material or surface to support colonisation of one or multiple groups of living organisms. Specifically, it refers to the colonisation of vegetation or other forms of plant life. The colonisation of the material usually happens over time, creating primary, secondary and tertiary bioreceptivity (shown in Figure 8). Bioreceptivity is used as a means to integrate greenery and nature into urban environments. By designing buildings and urban landscapes that are bioreceptive, it is possible to create more sustainable and ecologically diverse resilient environments that enhances biodiversity, air-quality and well-being(Guillitte, 1995).
The 'reefs' of Urban reef can be seen as bioreceptive living artefacts that combine man made materials and techniques such as ceramic firing, algorithmic design and 3D printing in order to make a resilient and evolving habitat. This will allow a large diversity of species to return to urban areas(Urban-Reef, 2023).

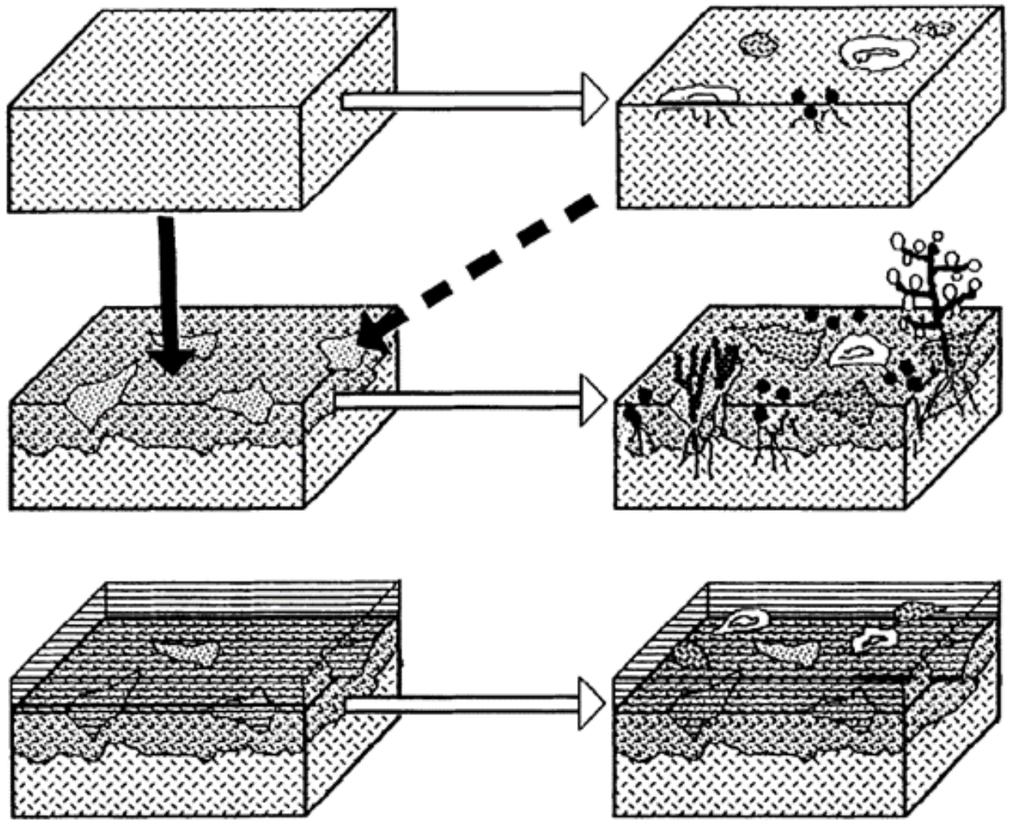


Figure 8. Bioreceptivity explained (Guillitte, 1995)

Multispecies design

Over the past few years, the field of multispecies design has emerged, bringing together design, architecture, and ecology. This approach recognizes that humans are not the only actors in the design process and that designing for the needs of non-human species can result in more resilient and sustainable environments. Multispecies design considers sustainability not only as an outcome of the design process but also as a behavioural attitude during the design process, according to Gatto and McCardle (2019).

Multispecies design focuses on the coexistence of multiple species in urban areas, in contrast to the traditional view of exclusive human agency, similar as to how Urban Reef focuses on other species that co-exist with humans. It considers how different species influence the flows of the ecosystem and, consequently, affect each other's lives. Multispecies design also takes into account the potential impact of each design decision on the well-being of both humans and non-human species, as highlighted by Dürbeck, Schaumann, et al. (2015).

More than human design

More than human design expands upon the multispecies design concept by focusing on the interconnected network of ecological relationships between humans and other living species. This design perspective challenges anthropocentric views that prioritize humans over other species and highlights the interdependence of all living entities. Non-human entities such as plants, animals, and other intelligent beings are considered in the design process to create new interactions and meaning between humans and non-humans that challenge biases and blind spots(DiSalvo and Lukens 2011).

The more than human design approach integrates knowledge from various fields, including artificial intelligence and biology, into the design process to create inclusive and holistic environments. By incorporating the perspectives and needs of non-human entities, designers can create more sustainable and resilient systems that benefit all living beings(DiSalvo and Lukens 2011). Likewise, this is what Urban Reefs aims to achieve with their 'reefs' contributing to this across many urban areas.

Nature connectedness

Nature connectedness is a term commonly used in psychology that refers to the relationship between a person and the natural world. Nature or 'the natural world', as defined by the Oxford dictionary, encompasses the physical environment created by the Earth, such as flora, fauna, and landscapes, and is distinct from human-made creations. A person who experiences a high level of nature connectedness feels a deep emotional attachment and sense of identity with the natural world. This connection often leads to a stronger appreciation for nature and a greater likelihood of engaging in pro-environmental behaviours. Nature connectedness can have a significant impact on our attitudes, behaviours, emotional responses, and overall experience of the world. While primarily studied in environmental psychology, the concept is increasingly relevant in the field of urban design (Richardson et al., 2019). 'Nature connectedness' is sometimes referred to as 'human-nature connectedness'.

Sustainable transformations & the human nature connection

As said by Preiser et al. (, 2017), in his Critical Post-humanism framing, sustainable transformations are only created when we as humans learn new ways of interacting with the natural environment around us. In his framework, Preiser mentions that on multiple levels of existence there should be a responsibility towards otherness such as nature or vulnerable communities. It is about learning the language and signs of who has the power to act and the power to be affected. And after this has been acknowledged, sustainable transformations can happen by allowing for different actors to co-create spaces of engagement and orders of autonomy, solidarity and security.

So all in all, it is important for humans to recognize the language of nature and the signs of how they do or do not have the power to act in order to influence the nature around them. It is about restoring the human-nature connection. This human-nature connection is a crucial part in creating sustainable transformations, as shown in the virtuous circle of sustainability (see Figure x) it influences sustainable norms and values as well as policies. (Barragan-Jason et. Al, 2021)

Currently when it comes to our perspective of nature, the focus is on the services (also known as ecosystem services) that natural entities provide for human. There needs to be a (in)direct use for nature where we as humans can exert undue control (also known as dominance) over it, this consequently has led to a toxic relationship with nature. Richarson et al. (, 2017) constructed a framework "The Pathways to Nature Connectedness Framework" which counters these dominant types of relationship that are prevalent in society today – and helps guide to relationship that can help humans form a better relationship with all of nature, humanity included.

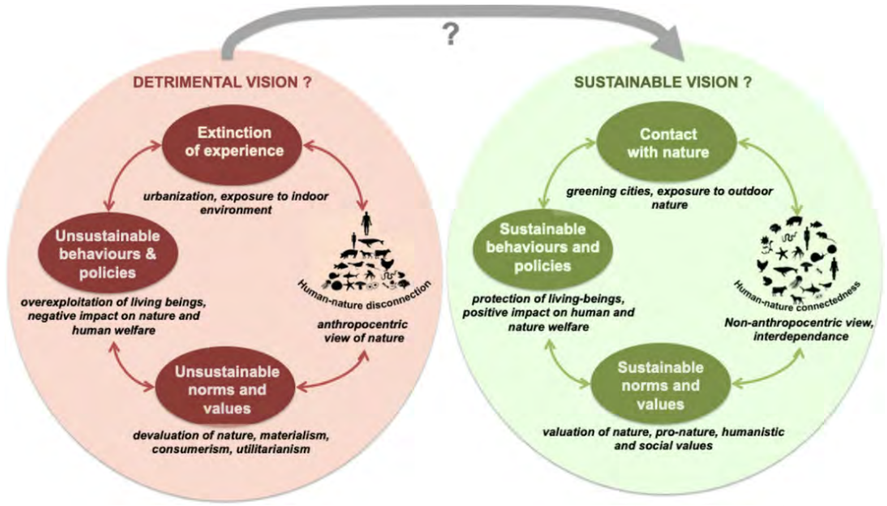


Figure 9. Sustainable transformation through nature connectedness (Preiser et al., 2017)

Pathways to increasing the human-nature connection

According to Richardson et. al(, 2017) there are five pathways that can be applied to increase the human-nature connection: contact, beauty, meaning, emotion and compassion. These pathways are based on five biophilic values. More information on the pathways can be found inTable 1 (Lumber, Richardson et al., 2017).

Biophilic Value	Definition	Pathway	Definition
Naturalistic	Pleasure from contact with nature	Contact	The act of engaging with nature through the senses
Aesthetic	Appeal of nature's physical beauty	Beauty	The perception of aesthetic qualities including shape, colour and form that please the senses
Symbolic	Expressing ideas through nature based language and metaphors	Meaning	Using nature or natural symbolism to communicate a concept that is not directly expressed
Humanistic	Emotional bond with, and love for nature	Emotion	An affective state or sensation that occurs as a result of engaging with nature
Moralistic	Ethical concern/judgements and revering nature	Compassion	Extending the self to include nature, leading to a concern for other natural entities that motivates understanding and helping/co-operation

Table 1. Five pathway to nature connectedness (Lumber et al., 2017)

These pathways should be applied to society in the right way to reap the most benefits for a sustained nature connectedness . Lumber et al. (, 2017) mentions that easily accessible urban green space does not necessarily have to be engaged with, it should be carefully chosen which interventions to insert into society and how they should be adjusted to society following the pathways. Examples of interventions that follow the pathways in ways that create a more nature connected society can be found in Table 2 below.

In the mentioned sources there are recommendations of which interventions to apply, for example "landscape design and art installations should prompt sensory engagement with nature"(Lumber, Richardson et al., 2017). However there is currently limited research that helps guide in ways to adapt landscape design and art installations to prompt sensory engagement in a way that increases the human-nature connection.

Pathways	This pathway is about the individual …	We need to create a society where people …	Potential Interventions (see recommendations section for details)
Contact through the Senses	Tuning in to nature through the senses.	Notice and actively engage with nature, spending time fully experiencing nature with all their senses.	Landscape design and art installations to prompt sensory engagement with nature.
Emotion	Feeling alive through the emotions nature brings.	Engage emotionally with nature and find happiness and wonder in nature. Note the good things in nature, the joy and calm that they can bring. Embrace nature at times of sorrow.	The creation of spaces to enjoy the good things in nature.
Beauty	Noticing nature's beauty.	Find beauty throughout the natural world. Every day, take time to appreciate beauty in nature and engage with it through art or in words.	Transport policy should celebrate the beauty of the natural world visible from trains and roads.
Meaning	Nature bringing meaning to our lives.	Explore and express how nature brings meaning to their lives. Notice how nature appears in songs and stories, poems and art, how special places are natural spaces. Celebrate the mystery, signs and cycles of nature.	Direct arts funding to celebrate our connections with the natural world through festivals and performance.
Compassion	Caring and taking action for nature.	Think about what they can do for nature. Take actions that are good for nature. Recognise shared life stories and be part of the community of nature.	Resident management of public wildlife-friendly gardens.

Table 2. Pathways to nature connectedness and examples of potential interventions (Richardson et al., 2020)

As has been identified by Richardson et al. (2020) the statistical importance for nature connectedness is the largest with emotion and compassion and thirdly with contact. However according to Richardson et al. (2020) the estimated scale of societal relevance is the largest when it comes to meaning, emotion and sensory contact (Figure 12).

Adjusting the pathways to living artefacts

Giaccardi and Karana (2015) proposed that there are four levels of material experience for artifacts on a product perspective: sensorial, affective, interpretive, and performative. These levels appear to have some overlap with the five pathways presented by Lumber et al. (2017), but Lumber et al.'s framework extends beyond the product level to a broader context. When it comes to products, people tend to focus initially on the sensory and emotional aspects of the product, as well as what they believe the product represents and its intended function. As they continue to interact with the product over time, some individuals may start to reflect on how it relates to other aspects of their life and its overall significance.

When researching the reefs it is important to take into account the levels of material experience as well as the larger context of the artefact and the user.

In the research of Richardson it is mentioned that knowledge based activities do not have a significant impact on the nature connectedness of individuals(Lumber, Richardson et al., 2017). However if a pathway of nature connectedness(like sensory contact) is combined with a knowledge based activity there can be an increase in nature relatedness.

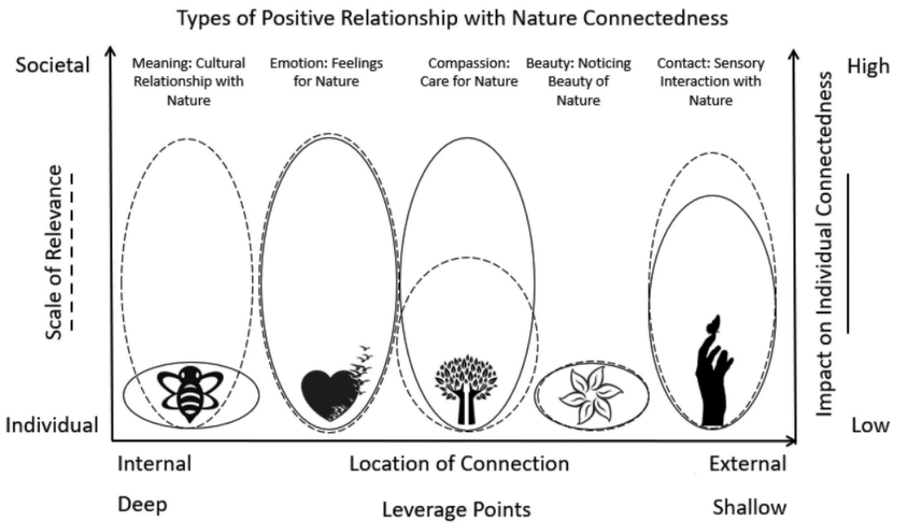


Figure 10. Types of positive relationship with nature and scale of relevance and leverage (Richardson et al., 2020)

Citizen science

Citizen science is any activity where citizens (without scientific backgrounds) are involved in scientific research (eu-citizen-science, 2023). Citizen science has the potential to have a large impact on society because it brings together scientists, citizens, policy makers and more. Within citizen science, citizens can be involved in different stages of the research. From the start of constructing the research questions and methods, to collecting data and to publishing results. Examples of common citizen science approaches include bird spotting, plant monitoring and testing bodies of water.

For small companies like Urban Reef that are doing a lot of scientific research while they are developing their products, citizen science can be a useful tool. In this way Urban Reef has a bigger research capacity and they additionally involve the public in the development of their product which can have a positive contribution for future sales.

Bioreceptivity Research Reefs

As a young start-up, Urban Reef is still conducting extensive research on the development of their prototypes, and as such, there are numerous scientific questions that remain unanswered, particularly with regard to the bioreceptivity of their reefs and the relationship that these reefs can establish with humans.
Urban Reef is currently exploring ways to enhance the bioreceptivity of the reefs, thereby supporting a wider variety of life forms. Research has demonstrated that algae/cyanobacteria can serve as a nutrient source for mosses and other types of vegetation, while chlorella vulgaris algae have proven optimal for colonizing ceramic surfaces as well as 3Dprinted surfaces(Kardel, Carrano et al., 2015), see Figure 13.
Another critical question concerns how people should interact with the reefs, whether and how they should "care" for the reef, and how this caretaking can benefit the reef and promote the development of a thriving habitat for urban wildlife.

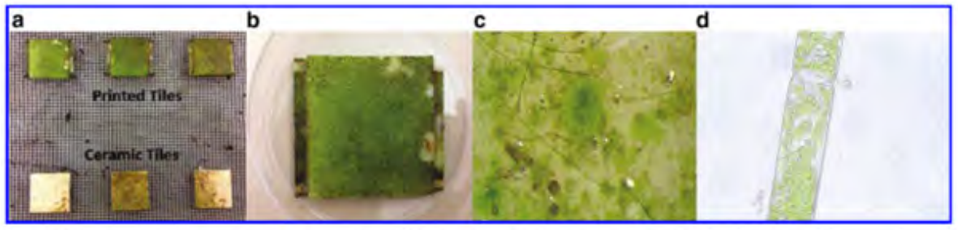


Figure 11. Testing of 3D printed tiles with chlorella vulgaris algae (Kardel,Carrano et al., 2015)

The role of living artefacts in modern society

Currently there are not a lot of urban living artefacts in the modern society and many of these artefact are viewed as novel and strange. Some of these artefacts focus more on increasing the biodiversity of the city and some focus more in increasing the awareness of non-human species in the city.

As mentioned bu Cheok et al in 2008 ''In the fast paced modern world people are generally too busy to monitor various significant social or human aspects of their lives, such as time spent with their family, their overall health, state of the ecology, etc…''. In order to make people more aware of the these things that are significant aspects of their lives, people need external stimuli. Currently, one of the few ways that people stop to notice and to care is if they see the immediate value of something for their lives(van den Broek, 2022).

In a more than human perspective we do not see these Reefs only as a valuable tool for humans but as a separate living entity with its own wants and needs. Then the question poses; What kind of interaction is needed between humans and other species to feel connected so that they can help build a resilient ecosystem? How do we communicate the perspective of the other species while at the same time increase the connection between human and nature?

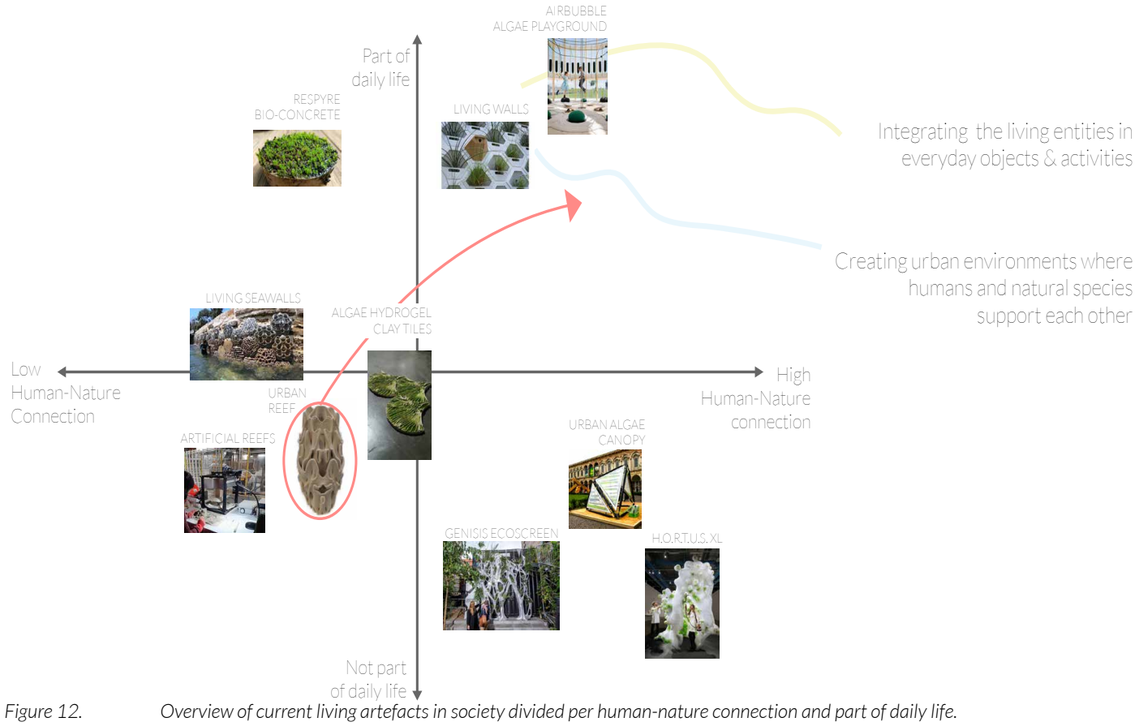


Figure 12. *Overview of current living artefacts in society divided per human-nature connection and part of daily life.*

5. Exploratory research human-nature awareness & the reef

On the 30th of October there was a science day organised by Science Centre in The science Centre, Green Village and around it. Here several science projects were displayed in an educational and interactive way to engage families in Delft with the scientific subjects (There will be many parents with young children from 3-12 years). Urban reef was one of these projects on this science day.

Main research questions

On this day I had the chance to get information from many visitors that day as a first exploration on the social domain. The main research questions that I wanted to have answered on this day are:

1. What do urban citizens experience as nature in the city?
2. How do people experience the urban reef and it's livingness?
   A. Does the amount of livingness influence their experience of the reef and nature?
3. How would people want to take care of the urban reef?
   A. Does it differ with the amount of livingness on the reef?

Methods

1. Observation

Three Reefs in different states were observed: empty, populated with living species, and with dried-out dead plants. I monitored people's reactions to each Reef, noting their level of attention, proximity, and interaction. Manual observation and camera pictures were utilized.

2. Questions via Interactive Posters

Interactive posters and sticky notes were used to pose questions that indirectly addressed the research inquiries. The specific questions and corresponding answers are provided later in this Chapter.

3. Making clay seed bombs:

To engage children and encourage sensory exploration and creativity, I facilitated the creation of clay seed bombs by the children and their caretakers. These seed bombs, made of ceramic clay, represented the Reefs and could be placed in their garden, balcony, or street. Additionally, the activity aimed to raise awareness among children and caretakers about contributing to biodiversity in their neighbourhood.

Choice for method & design

The chosen methods serve multiple purposes. They strike a balance between my graduation goals, the desires of the Urban Reef, and the expectations of the Science Centre for the science day. The Urban Reef wanted a representative display of their Reefs, allowing people to observe and inquire about them.

The Science Centre aimed for an engaging experience for families with young children, with an interactive element. To meet these objectives, I showcased three similar Reefs in different states: empty, populated with various species, and with dried-out plants. This provided a comprehensive representation of Reefs and nature, offering ample opportunities for observation, sensory exploration, and questioning. Additionally, clay seed bombs were included to promote interactivity and raise awareness about nature.

The interactive questions were carefully designed to address the research questions. The first question aimed to obtain responses regarding people's perception of nature in the city, revealing what they predominantly notice and how they define nature. The second question explored people's aesthetic impressions of the Reefs by using a diverse range of descriptive attributes. The third question invited participants to associate the types of species they believed could inhabit the Reef, utilizing anthropomorphism to resonate with emotions and engage young children(Lumber, Richardson et al., 2017). Finally, participants were asked how they would care for the Reefs in different states, assessing potential caretaking interaction.

Estimated visitors of Urban Reef stand: 150-250. Engaged in activities: 80-100

Research limitations

Due to the setting of this research, there were several research limitations. Firstly, the research heavily focused on children, only partially on parents/caregivers, which increased the likelihood that many participants, mostly young children, did not understand the questions properly. Another factor was that many children may have viewed the interactive posters more as a game rather than serious questions, leading to varied and inconsistent answers. Moreover, the participants could have been significantly influenced by the answers of people before them as well as by their family, although this influence does not necessarily have to be considered a big limiting factor, as people's perceptions are often shaped by those around them. Additionally, the research day was very busy and resources were limited, making it challenging to make comprehensive observations of everyone, despite some assistance. Due to these various limitations, the results of this research will serve more as a guide for a new research direction and will be compared to existing literature later in this Chapter.

Results

1. What do urban citizens experience as nature in the city?

People largely associate trees, plants, forrests and birds with nature in the city. Nature is mostly related to bigger urban green areas such as parks or forrests.

They can mention quite some different species of animals however very few species of plants or organisms.Overall people do not seem so aware of the nature around them and it takes some time to think of examples of nature. There is a lot of room for improvement.

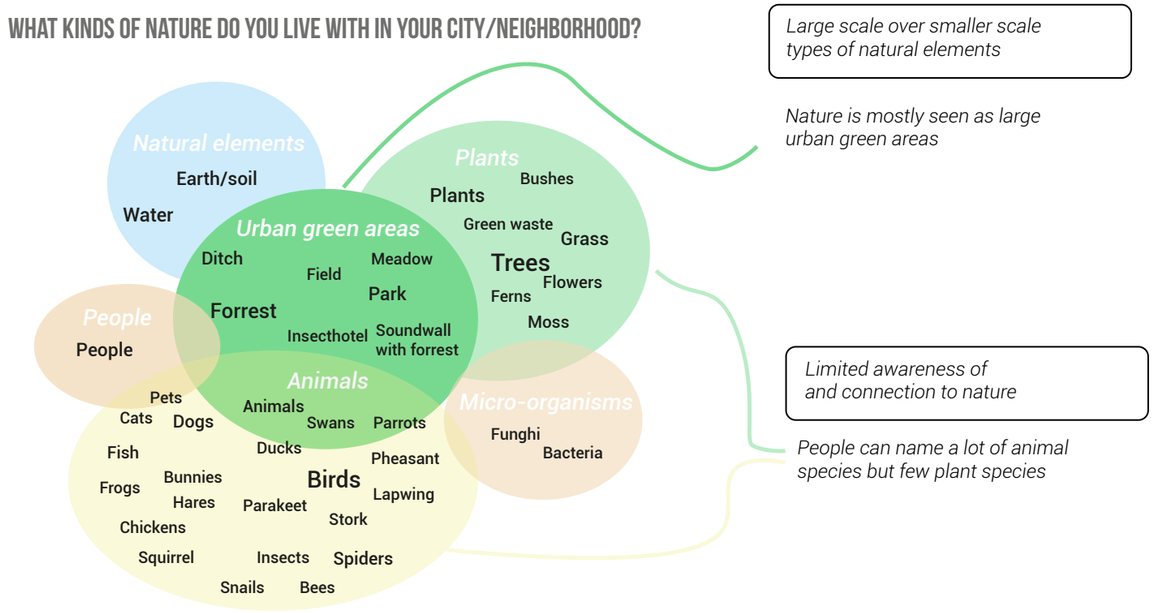


Figure 13. Experience of nature

2.How do people experience the urban reef and it's livingness?

a. Does the amount of livingness influence their experience of the reef and nature?

People estimate that the least amount of species living on reef A and the most amount on reef C. The type of species also vary per reef, most likely due to the plants that they can see on the reef and the animals they associate with that.
People are very curious and interested, they think it looks strange/peculiar/interesting however on the other side they think it is pretty, they have not seen anything like it before.

Reef A is mostly seen as Pretty, Clean, strong and Elegant. And as the livingness changes on reef B they view it less in this manner and view it as more interesting and clumsy.
Reef C people view as more Old, Vulnerable, Ugly and Dirty. However some people still find it Pretty and Strong. The more chaos the more opinions vary.

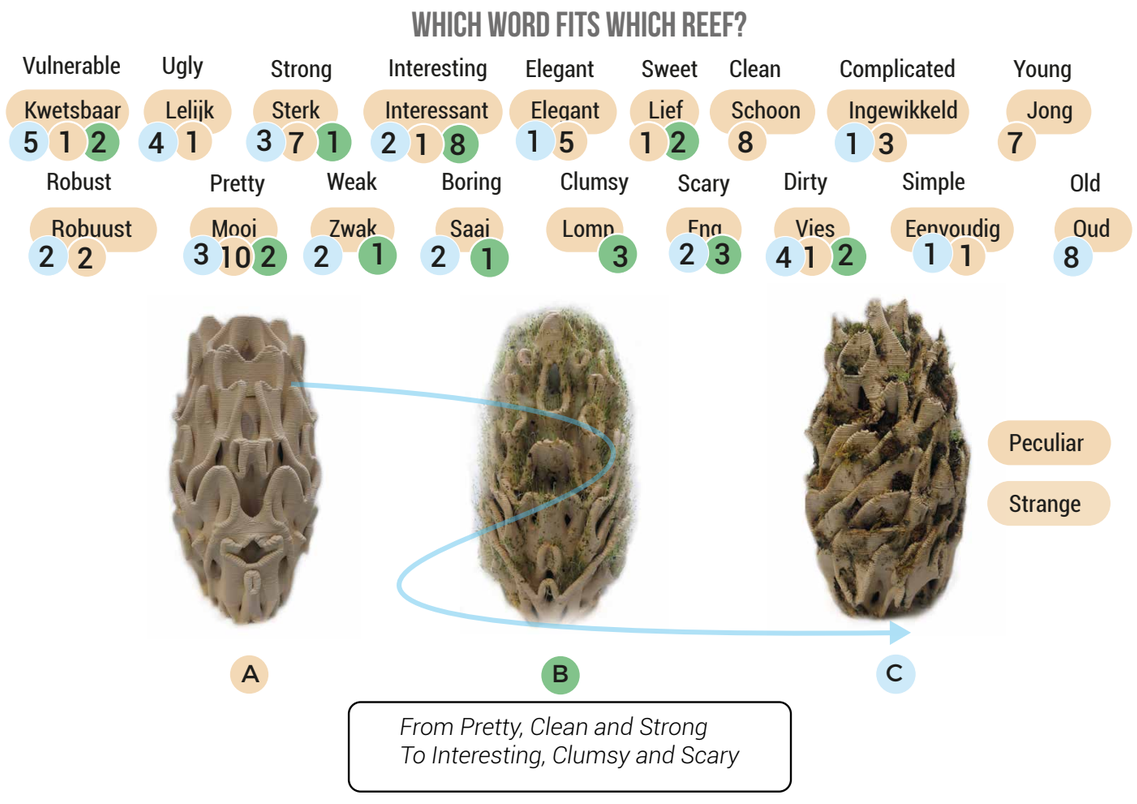
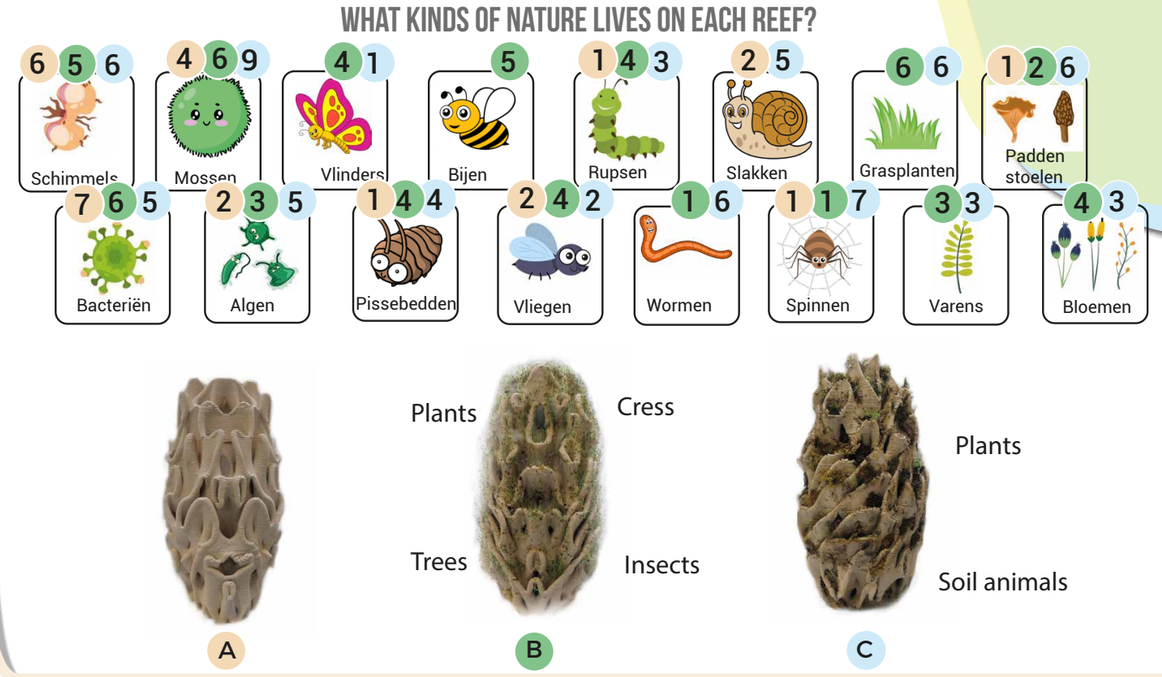


Figure 14. *Experience of Reefs - Attributes*



3.How would people want to take care of the urban reef?

Most people would give the Reef water and sun. Some also would give it soil, plants and even love.
The less livingness the more inclined people are to take care of it. (They presumably would like to see the living artefact change and come to life)

Most people want it in their garden or kitchen (for herbs) for personal benefit. Some also think of other animals that can live in it and they can help these animals by giving the urban Reef as a house/habitat.

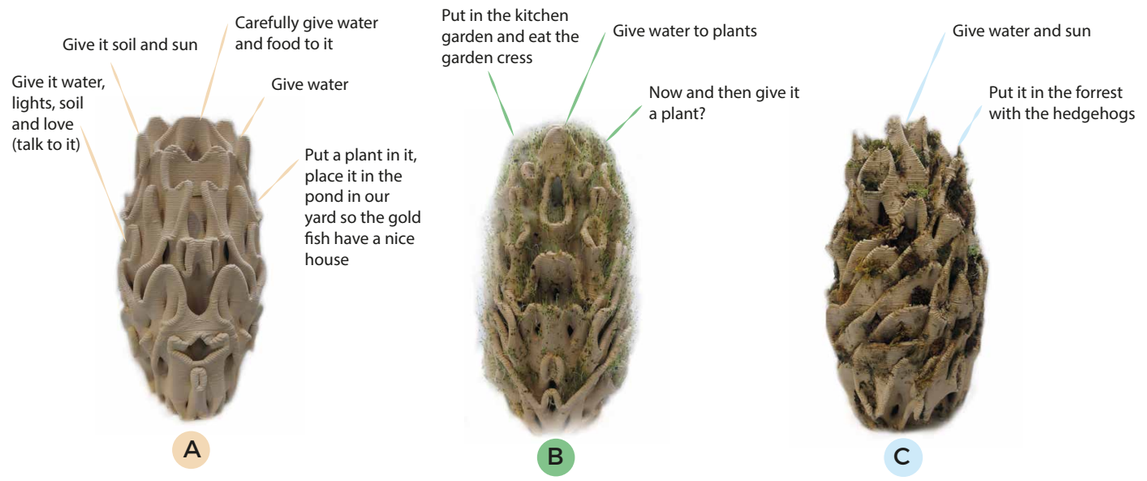


Figure 15. *Taking care of the reefs*

Other findings

The creation of seed bombs and participation in answering questions demonstrated that engaging citizens in hands-on activities stimulates their interest and engagement in the subject of nature and biodiversity. Many participants inquired about the clay seed bombs and discovered new ways to contribute to local biodiversity.

Furthermore, it was observed that parents can learn through the curiosity of their children, as they were prompted to answer their questions. Additionally, many of the caretakers and children were observed touching (or smelling) the Reef, to fully experience and by that process the Reefs composition and nature. Overall the interaction with the Reefs itself was very short and attention and/or interest diminished quickly. However the attention and interest for the claying of seed bombs was higher as this required action and input. Overall, these findings highlight a strong curiosity towards nature and a need for increased interaction with the natural environment.

Discussion

The research findings indicate a limited awareness of nature among the participants. Only a few individuals consider themselves as part of nature or contemplate the existence of micro-organisms. Most people tend to associate nature with large animals and expansive green areas like forests and parks, with fewer individuals able to identify different plants or insects. These findings align with previous research by Hooykaas, Schilthuizen et al. (2020), which also revealed that “laypeople” possess limited knowledge of biodiversity and their “perceptions are primarily focused on charismatic and exotic species”.

A clear relationship emerges between people’s attribution of interesting to the Reef and their estimation of the number of species present. Reef B and C, which were perceived more times as interesting, were associated with a greater number of estimated species. This underscores urban citizens’ profound fascination with nature, wherein the more they can observe, the more captivating it becomes. However, it is challenging to draw definitive conclusions as opinions vary greatly, and participant responses cannot be traced across multiple questions.

Overall, the research highlights the desire of many individuals to care for the Reef and its associated natural species. Conversely, some people view the Reef as a resource for personal gain, such as growing kitchen herbs or sustaining pond fish. This reflects the anthropocentric view held by many citizens, where humans exercise dominion over nature (Merchant,

2006). Additionally, different worldviews are evident, predominantly an egalitarian worldview wherein nature is seen as fragile (Lazrus, 2015). The research underscores the importance of worldviews in shaping how people perceive and treat nature, thus warranting consideration in future studies.

The activity of making clay seed bombs reveals the potential to enhance awareness of nature and strengthen the human-nature connection through engaging artistic activities. This finding aligns with the research of Lumber, Richardson et al. (2017), which emphasizes the significance of sensory contact in fostering this connection.

All in all, the research emphasizes the opportunities to improve awareness and foster a deeper connection between humans and nature. Urban citizens, generally exhibit a high curiosity towards nature, and when given the chance to pause and observe, they seek to interact with and understand nature better. Sustaining their interest and attention, however, is key.be in keeping the interest and attention of people.

6. Nature connectedness through citizen science

In this Chapter the main goal of the research as well as the subgoal will be elaborated. Next to that an outline of the research method is given. Later the results and discussion of the research will be added.

One ‘Research through Design approach’ to addressing both questions of Urban Reef as well as this graduation thesis simultaneously is through citizen science. In a citizen science pilot experiment where local citizens become scientists and assist Urban Reef in investigating whether chlorella algae can grow and colonize the reef. The process of researching the algae requires meticulous attention and care, preserving the reef at regular temperature and moisture, environmental condition monitoring, and algae growth tracking through pictures. The entire process demands a high level of sensory engagement, one of the five pathways to nature connectedness mentioned previously. During this process people the hypothesis is that participants will start to connect differently with nature and pay more attention to the signs of how the eco-system is doing.

By interviewing participants on their citizen science experiences and facilitating co-creative sessions, Urban Reef can gain new insights into the impact of the caretaking process on nature connectedness. What do people feel throughout the process, how connected to nature do they feel, and what novel ways of perceiving nature emerge as a result? And lastly, how can this be used to prepare for new citizen science experiments that will ultimately further their reef designs to better fit local citizens and the environment.

Research & design challenge

With this new citizen science project, the challenge is to discover if and how algae can be used on the reef and then supported by people taking care of it. Additionally, to discover how people feel towards the reef and nature and how this process of caretaking changes that. Specifically, what the ways are that make people feel connected and more caring for nature. Lastly, it is to identify opportunities for Urban Reef to adjust and/or supplement their current design so that it encourages the right kind of engagement to improve the nature connectedness as well as the local biodiversity.

Main goal research

Researching if and how contact with the urban reef through citizen science affects the nature connectedness of people. Here citizen science will be used as an activity that is focused on the contact with senses and compassion (2 of the 5 pathways to increase nature connectedness).

Subgoal of the citizen science

The goal of the citizen science itself is to see if algae (chlorella vulgaris) can colonize the urban reef with the help of people under normal at home circumstances (room temperature, in a glass bulb, in a bright room).

Research Method

The research will consists of 5 parts, with 2 optional parts that can de conducted by Urban Reef outside of the scope of this graduation project. The first part starting already with the finding of participants and measuring the base line of nature relatedness. The second part conducts of a co-creative session where the participants will have input on their own citizen science project and adjust my recommendations to their liking. In the third part, the participant will receive a reef at home to take care of for twee weeks. During the last week all participants will have an individual interview on their experiences, this is part 4. The final part is a co-creative session where everyone discusses the results and ideates on new directions. Optionally participants can put the reef in their garden and Urban Reef can keep in touch with participants to see how the Reefs are doing over time.

Part 1: Finding participants and Measuring Base line – Day -5

Time: 5-10 mins
Needed: Google form

The possible participants will fill in a short survey answering some general personal questions as well as the nature relatedness scale (see Appendix B). This will establish the baseline of nature connectedness that this individual has. And based on these answers some participants will be selected that have a relatively low nature relatedness score.

Part 2: Co-creative session with all participants- Day 0

Time: 90 minutes
Needed: Example Reef with taking care kit. Example form/ booklet for measurements. A3 papers, post-its, pens and markers.

At the start of this session participants will first sign the informed consent form for the complete research project. Next, the original plan for part 3 will be presented and their input will be asked on the plan. The main question is if it is doable and how it should be adjusted to their daily routine. Next to that other input on how to conduct the research is welcomed. If time allows some first impressions on the reef will be asked and expectations will be set.

Part 3: Citizen Science Experiment - Day 1 - 14

Time: 5-10 mins daily
Needed: 5 times: Urban reef, chlorella algae solution + nutrients, extra nutrients + spray bottle, hygrometer/ thermometer, app to measure sunlight, glass bulb, plate for the reef/glass bulb, paper booklet to fill in measurements, pen. Guidebook on how to install, take care of and monitor the reef.

Every participant will get their own mini urban reef + research set-up kit (incl. algae, sensors, glass bulb etc). The researcher (me) will help find a spot near a window where the set-up can be placed and the algae will be applied by the participants with guidance of the researcher. The researcher will explain how to conduct measurements and the first measurements will be done by the participants as the researcher observes. The following days the participants will conduct the measurements without the researcher present. They will send a picture over WhatsApp and write down the measurements/observations/thoughts. (This process will be adapted according to the outcome of part 2)

Part 4. Individual interviews for Experience & Nature Relatedness (somewhere between day 8 and 14)

Time: around 30 to 60 minutes
Needed: Interview questions, Microsoft form for nature relatedness scale. Phone for audio recording.

In this part, participants will be asked to fill in the nature connectedness form again. Next to that there will be an interview to ask some questions about their experience "taking care" of the Reef and more details on their current connection to nature and how it has been influenced. A list of the questions that will be asked can be found in Appendix C.

Part 5 – Co-creative session to close of research – Day 14

Time: around 90 minutes
Needed: Example Reef with taking care kit. Example form/ booklet for measurements. A3 papers, post-its, pens and markers. Results from interview/experiment.

During this last co-creative session we will discuss everyone's experience in the group. We will discuss the results of the research and discuss possible new directions. Next to that the anonymised results from the interviews will be presented and we will discuss together on how each individuals nature relatedness was influenced by the experiment and why. Lastly we will conclude with ideating on possible adjustments to the reefs.

**Part 6 – optional putting reef on balcony or garden*

Time: Depends on people
Needed: Garden/balcony

Let people put the reef in their garden/balcony/street and people are free to do what they want (take care of it or not).

Pilot research

Since the 28th of February I started an experiment at home and on the 23rd of February at Urban Reef with 3 media for the algae on the Reef: agar agar, agar & hydrogel and water (more information see Appendix D). The Reefs at Urban Reef have been showing visual progress and became significantly more green over the course of 1 week(Figure 18-20). With the agar agar media showing the most change (Figure 19) .

The reefs at home barely showed any visual change, only slightly on the bottom of the right one(agar agar), after one week (Figure 21). Next, I tried another nutrient solution (BG11) with again hydrogel to see if this would create quicker results. Agar Agar was not used because this was a hassle with heating and cooling down (without compromising the algae), which was estimated not be feasible to do with the participants and moving the reef. The hydrogel solution with BG11 already showed a significant colour change after 3 days. (Figure 22 &23) This proved that a hydrogel solution with BG11 was the most convenient because it attached more to the reef and it was easy to apply.

Next to that, I asked my roommate to do daily measurements and fill in a survey. Her feedback made sure that I could make the form more understandable for the research participants. Changes like clarifying the front and back side, giving some examples of giving attention and more were integrated into the new version of the form.

Figure 16. Pilot test at Urban Reef : Water medium

Figure 17. Agar agar medium

Figure 18. Hydrogel medium

Figure 19. First Pilot test at home Reefs (From left to right: Hydrogel, water, Agar)

> *"The question of what do you see is a bit vague, you could add some examples (more greening or something) because maybe people dont know what to look for. The left and right side for pictures is confusing, maybe sunny/shady is better? "*
> *(Pilot reasearch participant, 2023)*

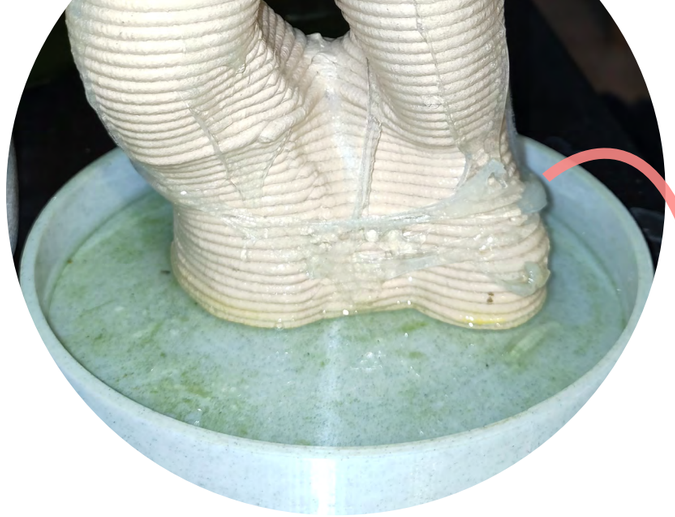


Figure 20. Final pilot test day

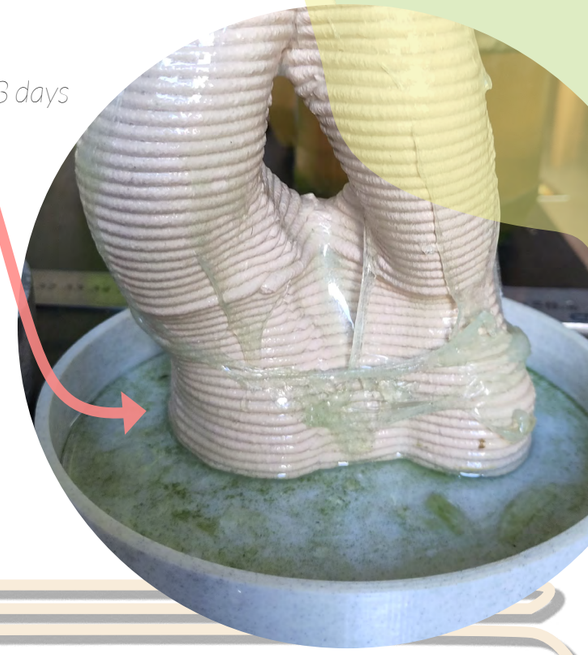


Figure 21. Final pilot test day

Results from the research

After a kick-off session, all the participants took a Reef with a hydrogel layer of algae home to take care of and look after for two weeks. Three out of five participants did daily measurements and care taking, one participant missed two or three days, one participant only did measurements for a total of five days. The results from the experiment can be viewed in Figure 24, more details can be found in Appendix E.

Figure 22. Kick-off session a participant applying Hydrogel

Figure 23. Overview kick-off session

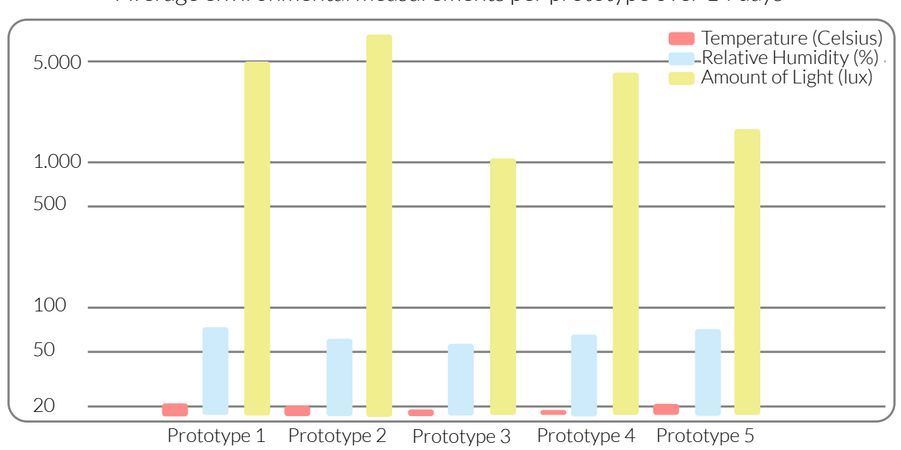
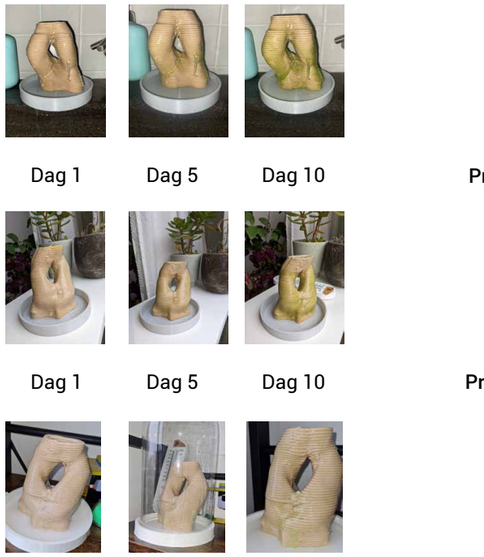


Figure 24. Average environmental measurement per prototype over 14 days

General results of the citizen science experiment

The research showed that the amount of light has the most influences, the more lux the quicker the growth of the algae (both with natural light as well as artificial light). Next to that, a steady temperature (between 18-23 degrees Celsius) and high relative humidity (50-80%) is essential to allow for a steady growth. Additionally, the direction of the light has a lot of influences on the location of the growth. The side that received the most light clearly had the most growth compared to the side of the reef that received less light. Overall the research showed that it is possible to have people take care of the reef with algae at home.

During the research participants were given the freedom to change the way that they took care of the reef. The experiment shows that they experimented with some other placements, other intervals of giving water and they used help of partners/roommates when necessary. Furthermore participants started to think of other ways to give extra attention to the reef: smelling, touching, petting it etc.



* *minder voedings-stoffen en algen*

Figure 25. Results citizen science experiment

After the research ended and the reef was not kept moist anymore, the algae hydrogel started to dry out and peel off the surface of the reef. This shows us that the gel did not penetrate the material of the reef. It could be best to integrate an algae solution within the material of the reef instead of on top of it for further research.

Findings & Insights

Prototype 1: Underneath a growing light and next to a window on east side.

Prototype 5: Next to a window on south-west side.

Prototype 2: Under neath a window on the south side.

Prototype 4: Under neath a sky light.

Prototype 3: Next to a window on the north-east side.

from the interviews & final co-creative session

During the second week of the experiment I interviewed 5 participants on their experience with the citizen science experiment. The conclusions from the interviews are split into 5 topics which are each split into findings & insights, an overview can be found in on the following pages(the overall results and analysation of the interviews can be found in Appendix F). For participating in this research, particpants signed an Informed Consent (Appendix G) and additionally an Ethics plan (Appendix H) and Data Management Plan (Appendix I)) was made.

Note to reader: these participants explicitely gave consent to be identifiable in the thesis.

"He is starting to smell mossy and all the green spots are getting darker."
- Participant 5 on day 10

"After a busy day, I took a good look at Chriet (reef), poured water in and enjoyed the algae already growing on it. The one on the inside I think is becoming very beautiful."
- Particpant 1 on day 9

"Something already seems to be becoming visible, but maybe it's wishful thinking."
- Participant 4 on day 4

"Extra looks and a quick sniff of it. This afternoon, Yuri(reef) will get a visit from the housemates who are curious about him."
- Participant 4 on day 4

Experiences of citizen experiment

Findings

- All participants overall really liked doing the experiment and especially liked seeing a quick result.
- Some participants (2 out of 5) found it quite some effort to do every day for two weeks, however this was mostly due to some hassle with water leaking, manually putting the meter in and waiting, troubles logging in to the google form etc.
- Many participants (3 out of 5) integrated the measurement process into their daily morning routine, another participant completed the measurement process daily when coming home from his study.
- A few participants (2 out of 5) did mention that they would feel guilty when they did not (yet) complete the measurements.
- Lastly, it was mentioned by one participant that it could be more calm and mindful to fill in the measurement details on paper instead of on the phone.

Insights

- For people to help with a citizen science experiment over a longer period of time, the experiment needs to be low effort and not that time-consuming (less than 15 minutes per day, max 1h per week).
- Moreover participants of the research would like to physically see a result to have the idea that they are contributing to something. They need reassurance that they are doing well and would like to know what to expect from the research.

Human – Reef connection & mutualistic care

Note to reader: these participants explicitely gave consent to be identifiable in the thesis.

Findings

- All participants found that making the pictures as well as needing to spent time and attention on the reef created more of a bond (like a pet), otherwise the reef would feel more like a houseplant.
- Some participants gave the reef a name(Chriet (non-binary) and Yuri(male after Urban Reef- U-ree)), which instantly created a more personal fun bond. Other participants mention they need more time to form a bond and might give it a name later or not at all.
- The question of giving the reef some special attention made participants think more of creating another bond or interacting differently: some people touched, smelled or petted the reef.
- Some participants even started to automatically think about future development and planning of how they would (not) take care of the reef in the future.
- Additionally, spending attention to the reef with algae and giving it water made people more aware of the nature around us, that green deposit and puddles of water also have micro-organisms and that this is not necessarily bad like they had thought before.
- On the other hand, many participants mentioned that the gel, glass bulb and 3d printed structure made the reef feel less like a natural living object and created a feeling of separation between the person and the living object.

Insights

- The fact that participants had a conversation with loved ones about the reef and the growth of the algae made it more fun and created more connection between the participants and their loved ones.
- The more connected participants feel to the reef, the more they will share it with other important connections in their life.
- It showed that when people gave the reef a name they started thinking more about it as a living being and what it needs/feels, moreover they appear to check in on the reef more often.
- Participants were very curious to see change and progress, this progress feels like a personal reflection on their own performance (if they are taking good care of it).
- Many participants planned about how they would influence the growth on the reef in the future, there is a longing to help as well as control nature in a way.

Living Aesthetic & habitabilities

Findings

- When it comes to the living aesthetic of the reef many participants liked how the reef looked, mostly due to the organic shape and the natural colour. The natural light colour allowed the participants to clearly see a difference in colour due to the algae, it created a good contrast.
- Most of the participants viewed the reef as a natural object (4 out of 5) due to the algae, natural materials and the natural shape. However the glass bulb and 3D printed structure made the reef feel less natural. Many participants (3 out of 5) mentioned that the reef could look a bit more organic: mainly through more bulges and less smooth layers. The current reef is perceived as too perfectly 3d printed.
- Besides some participants (2 out of 5) view the reef as more of an art object that reminds them of an anatomical shape: two legs, part of a bowel or a vein. The fact that it looks like art can be good but on the other hand takes away from the natural appearance.
- Moreover many participants (3 out of 5) would like to adjust the shape of the reef to their aesthetic preference, their home as well as to their pets or local birds. Additionally numerous participants (4 out of 5) would like to help the reef along by planting plants in or around it as well as putting bird food in it.
- Lastly, most participants (4 out of 5) would want to use the reef as something functional for themselves and/or nature: a rain catcher, border of the garden, bird hotel, roof tiles. Some even mentioned concrete benefits they could gain from it like: shading, higher air humidity and temperature regulator. The more the reef can be integrated into the house/garden the better for the users.

Insights

- Overall the shape of the reef is preferred to have an organic/rounded shape that is not too perfectly smooth. In the case that the shape looks too similar to something from human anatomy the reef was mostly interpreted as an art object.
- Any natural species that can be added should be added in a natural way that does not require chemical components or methods. If nutrients or algae can be integrated into the reef it would be even better.
- The more space there is for personalisation of the reef to each person's preferences and environment the bigger the chance citizens will want to buy the reef and will develop an emotional attachment to it.
- Additionally citizens would like to have at least one part of the reef that they can influence, for example: add nutrients, change shape, add plants, give water.
- On the other hand people look forward to the reef being low effort and not needing a lot of maintenance.

Human – Nature connection in general

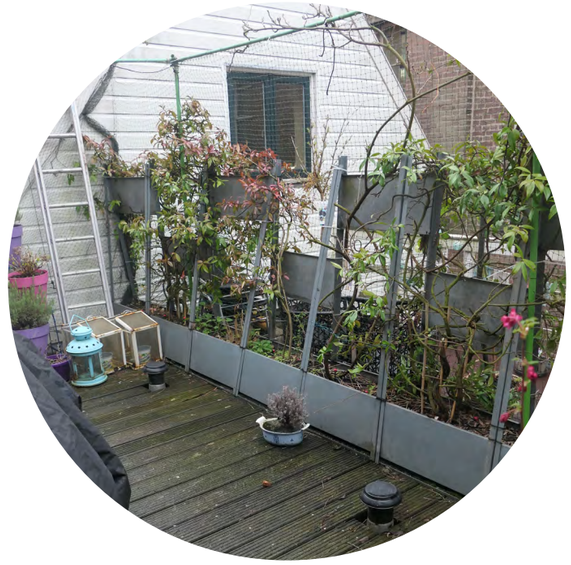
Findings

- Some participants mentioned that they were born with a connection to nature and/or grew up with it (2 out of 5) and others (2 out of 5) developed a connection later in life gradually.
- One participant had parents (in the country side) that always paid attention to nature and passed that on to the kids.
- One participant has a dog, which made them feel closer to nature. The dog brought them more in contact with nature during the dog-walks in the city and even look at nature from the perspective of the dog.
- Another mentioned that a vibrant social life in the city is important for them and contact with nature does not need to take away from that. The nature should come more to the city and to their life.
- Lastly, some participants (2 out of 5) were more busy with work or the people around them instead of learning about nature which in their perspective took away from their feeling of connection with nature.

Commercial Reefs

Findings

- When people have a rain pipe they are mostly interested in having a rain reef instead of rain tank (2 out of 5).
- Due to limited space around the rain pipe, the rain reef needs to not be too deep/wide (max 30x30 cm), however it can be very high.
- A participant mentioned that it would be best for them if you can adapt the rain reef to the available space in the garden.
- Another participant mentioned that it would be useful if they could then tap rain water from the rain reef to water the other plants in garden/house.
- When it comes to a cost price some participants are willing to pay around 200 to 500 euros for a (rain) reef, others would spend around 50 to 150 euros on it.



Note to reader: these participants explicitely gave consent to be identifiable in the thesis.

Results from Closing Co-creative session

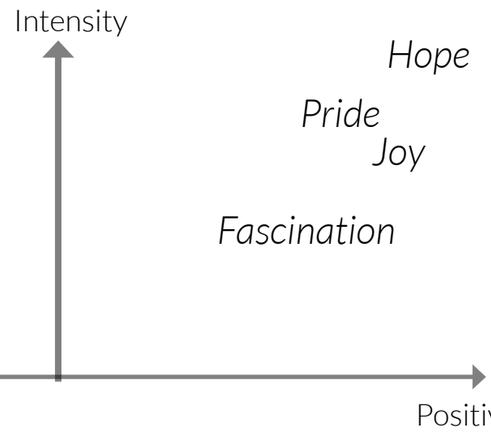
Living aesthetics

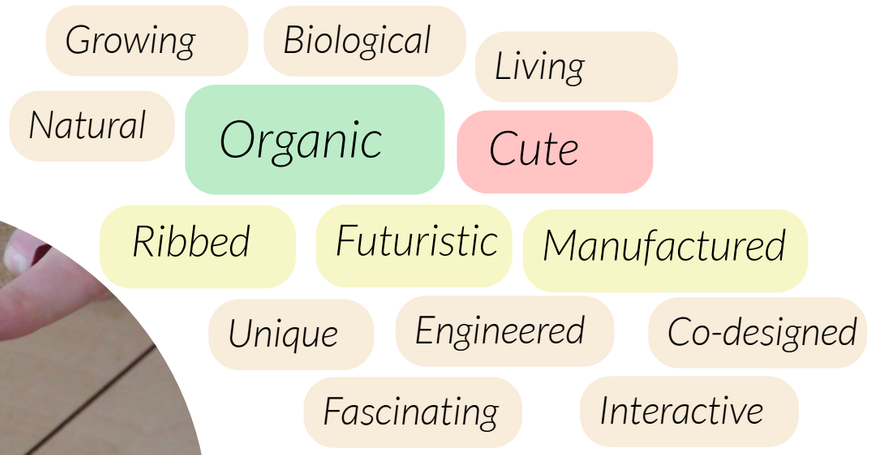
During the session it was mentioned multiple times that the reef looks organic and cute. Next to that participants mentioned it looked: 'futuristic', 'ribbed' and 'manufactured'. Additionally from a list of words used to describe living artefacts (add source) the following words were circled: Biological, living, natural, growing, unique, fascinating, engineered, co-designed and interactive.

Additionally people mostly felt emotions of 'Hope', 'Joy' and 'Fascination'. On the other hand some participants felt some feelings of 'Guilt' when it concerned the experiment and not (yet) completing the measurements every day.

Ideas on the nature connected pathways

During the session we did a brainstorm on each of the pathways of nature connectedness as well as a general brainstorm. The ideas are presented according to the pathways to nature connectedness.





Contact via the senses

- Larger shape with more cavities/plateaus/ bulges/holes that invite for exploring: Shape will invite people to explore with their senses. Create multiple habitats in one reef focused on different species.
- A cube shape reef with different internal parts.
- An assignment to make pictures/ care for the reef regularly helps people to connect to the reef via the senses.

Compassion

- Order a starter kit with it, that you can choose algae or moss or maybe wildflowers.
- Have patience, nature needs time to settle/ get used to the environment and grow.
- Don't try too much to bend nature to your will, let nature run its course.
- Grow a community so that people can exchange experiences, tips or pictures. Possibly also with a follow up in the nature.
- Tell something about what the reef adds to nature.

Emotion

- Let people be involved in the creation of the shape of the reef (size, colour, amount of bulge) online or clay it yourself.
- Show how the reef is made and show the people that are involved in making it.
- Give the reef as a present to someone so that an emotional connection is created. Passing forward reef.

Cultural Meaning

- A big reef that is like a fountain / park bench where people can also sit. A reef that makes you see you are also part of the eco-system (awareness function). Or integrated into the house: roof reef/ facade reef.
- Give information about the role of the reef within the eco-system. Put the reef on the street/ at the front of the house and put a QR code next to it with more information.
- Documentary about the reef and it's development, show at schools.
- Interactive website where everyone can share their reef (state) and on solstices celebrate the existence.
- On a school a reef like a vegetable garden.
- A forum, that is partly publicly accessible to show what you can do with it. Do you want to see more of the reefs then you need to buy a reef and you get full access to the platform and it's tips/tricks/info.

Beauty

- Add more holes and plateaus to have plants grow on. Put some plants on it for a quicker start of the growth. Add a more practical bulb or greenhouse.
- A greater variety of shapes so that people can choose a reef that fits with them.
- Let people describe what they see / feel/ smell. -> Create awareness that not all nature has to be big and compelling.
- Use different colour algae for more contrast/ liveliness/vividness.
- More organically shaped reefs

Overall discussion research outcomes

There were noTable differences among participants concerning various topics. Regarding the human-nature connection, most participants reported feeling more connected and aware of nature due to their engagement in the experiment. This can be attributed to the daily assignment of focusing on the living artefact. The participants paid greater attention to the Reef compared to a regular houseplant, resulting in a stronger sense of connection similar to having a pet. Without the assignment, the Reef would have likely been treated as a generic houseplant, easily forgotten and lacking a sense of connection. Similar findings were observed in the studies conducted by Lu and Lopes (2022) and Chen, Seong et al. (2021), where participants who were instructed to care for a slime mould watch and a Japanese bucket with pickled vegeTables also experienced a sense of responsibility and obligation. Additionally, many participants expressed an affective response towards the condition and appearance of the Reef, as highlighted by Lu and Lopez (2022) and Chen, Seong et al. (2021).

The use of algae and water in the experiment led some participants to become more aware of microorganisms in urban environments, such as those found on the streets, houses, and in puddles. The focus on microorganisms in this research helped participants recognize the presence of unseen nature in the city. Previous studies (Chapter 5) have shown that people often associate nature with large green areas and animals, overlooking smaller species like plants and microorganisms. However, living artefacts that incorporate microorganisms can play a role in raising awareness about these often unseen and overlooked species in our surroundings (Kim, Risseeuw et al., 2023).

The habit of noticing nature is a skill that can be cultivated through a series of reminders, routines, and rewards, similar to other habits. An initial cue or trigger serves as a reminder to become aware of nature. Urban citizens can then establish a daily routine of consciously noticing nature in the city. This practice can lead to a reward, such as experiencing positive emotions from engaging with nature. This reminder-routine-reward loop forms the basis for building the habit of noticing nature (J. Clear, 2023).

To develop this habit effectively, it is essential that the reminder and routine encourage individuals to mindfully engage with nature using all their senses (Richardson, Dobson et al., 2020). The research

underscores the importance of reminders that prompt people to reconnect with nature. It is likely that regular log-term reminders throughout daily city life are necessary for a sustained increase in human-nature connectedness, rather than just a temporary effect. Further investigation is needed to explore the long-term impact of caring for a living artefact on an individuals' connection with nature.

The study also revealed that when the task of looking after and paying attention to the living artefact was done together with loved ones, it became easier and more enjoyable. Many participants shared their progress and engaged in conversations about the artefact with their loved ones, resulting in feelings of happiness and strengthened connections. This finding aligns with the research conducted by Lu and Lopes (2022). Integrating the artefact into daily life and fostering a deeper connection can be facilitated by involving loved ones. By combining caretaking with existing household routines and connections, individuals can re-establish a bond with nature amidst the busyness of city life, involving people, work, and other commitments.

In this study, one participant reported that owning a dog increased their contact with nature and even allowed them to think of the perspective of the animal towards nature. However, the extent to which having a pet influences nature connectedness remains an open question, as it is a complex topic that requires further research, as was noted by Vining (2003).

On the other hand, the research indicated that when urban citizens learn more about nature and develop a deeper understanding of it, they tend to feel more connected to nature. Interestingly, it was found that knowledge itself is not necessarily the key factor, but rather a sense of curiosity towards learning about nature through engaging with nature (Lumber, Richardson et al., 2017). Overall, the findings of this study demonstrate the significant potential of knowledge-based activities such as citizen science in enhancing human-nature connection. Citizen science serves as a reminder for people to pay close attention to nature regularly, while also sparking curiosity and interest in learning about nature. Additionally, engaging in practices like citizen science provides individuals with a sense of involvement in the local community and fosters local innovation.

The research findings do have some limitations. Firstly, it is possible that many of the observed affective responses were influenced by the novelty of taking care of a living artefact. As this novelty wears off, positive affective responses may diminish and give way to other, potentially negative, emotions. For future studies, it is recommended to conduct longer-term research that allows for natural interactions and emotions to unfold in the participants' daily lives, providing a more comprehensive understanding. Secondly, this study had a limited number of participants, with only one male and four female participants, leading to restricted results. For future studies on this topic, it is advisable to have a larger and more diverse sample size, with a balanced representation of genders, including other gender identities, to obtain a broader range of insights.

The outcomes of this research contribute to a deeper understanding of the pathways to nature-connectedness, building upon the work of Lumber, Richardson et al. (2017), and how these pathways can be applied to living artefacts. Additionally, the study highlights the influence of ecological knowledge, a pathway that was previously not included, on creating a sense of connectedness. Moreover, significant overlaps were identified between the research fields of living artefacts and nature connectedness. This indicates the potential to develop a framework or guidelines that can inform the design of living artefacts, supporting high levels of nature connectedness for their users.

7.Design Guidelines for Human-Nature Connectedness through Living Artefacts

A set of design guidelines were formulated through an extensive review of relevant literature and user research, these guidelines are aimed at creating living artefacts that foster a strong connection between humans and nature (nature connectedness). These guidelines are primarily based on the five pathways proposed by Lumber, Richardson et al. (2017). Additionally, the pathway of knowledge was included based on research indicating its potential to enhance individuals' connectedness, especially when combined with at least one of the other pathways.

Moreover, the guidelines were tailored to the framework of living artefacts (Karana, Barati et al., 2020), encompassing Living aesthetics, Habitabilities, and Mutualistic care. Multiple iterations were made in collaboration with living artefact designers, researchers, and design students. Some explanation on these iteration is mentioned in Chapter 8.

The culmination of this process resulted in the final design guidelines, presented in this Chapter. The introductory card is featured on the following page, followed by Part 1, which directs designers to focus on selecting two or three pathways for their designs. Subsequently, Part 2 provides guiding questions to facilitate the further development of their design(s). Finally, a collection of example cards is provided, serving as inspirational references during Part 2.

Human-Nature Connectedness through Living Artefacts

Design Guidelines

This card set is meant as guidelines for 'living artefact'-designers to create designs with a high human-nature connectedness. You can apply the cards throughout your design process to your design ideas, concepts & prototype(s).

Part 1(A-G1): If the answer is yes to one or more questions, then you can apply the pathway. It is recommended to choose two to three pathways, in order to create a strong design. It can be possible to apply all of the pathways.

Part 2(A-G2): Select the pathways chosen in Part 1. Use the guiding questions to create and adapt your design(s). And view the accompanying example cards for inspiration.

Made by Dawn Verkerk

A1. Living Aesthethics

- Does the artefact contain natural characteristics (shapes & colors etc)?
- Is it an artistic artefact?
- Is it a wearable object?

Examples of Living Artefacts

Algae graphs (Lia Giraud & Claude Yéprémian, 2014)

Flavorium (Groutars & Risseeuw et al., 2022)

B1. Interactions

- Is there space for interaction?
- Is it part of the urban landscape?
- Can humans engage with the artefact in an artistic way?

Examples of Living Artefacts

Airbubble *(ecoLogic Studio, 2021)*

Living light lamp (Nova Inno-va team & Plant-e team, 2023)

C1. Affective Response

- Is there possibility for people to create an emotional attachement to it?
- Can the artefact be shared by loved ones or a community?
- Does the artefact help create a space that represents a natural environment?

Examples of Living Artefacts

Breathing shoe *(PUMA & the Fraunhofer Institute, 2019)*

Nuka Bot *(Chen. et al, 2021)*

D1. Habitabilities

- Are humans important to create a suitable habitat for the artefact?
- Are there multiple species interacting with each other?
- Does the artfact have a large effect on the local eco-system?

Examples of Living Artefacts

Biogarmentry (Roya Aghighi, 2019)

Genesis Ecoscreen (L. Lawson, 2019)

E1. Care & Compassion

- Does the artefact require care from humans to stay alive?
- Does the artefact support local (urban) wild life?
- Can the artefact elicit a feeling of compassion?

Examples of Living Artefacts

Slime mould watch (Lu & Lopez, 2022)

Living wall (D. Briscoe, 2018)

F1. Views of Nature

- Is it a cultural artefact?
- Does the artefact symbolize a larger meaning?
- Can the artefact be used in common rituals, traditions or routines?

Examples of Living Artefacts

Urban Algae Canopy *(ecoLogic Studio, 2015)*

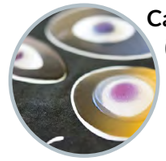
Living Coccoon *(Loop-biotech, 2023)*

G1. Ecological Knowledge

- Does the level of pre-existing knowledge about ecology affect the use of the artefact?
- Can the user(s) learn something about ecology through the use of the artefact?
- Can the artefact play a role in education?

Examples of Living Artefacts

Bio.Bolla *(ecoLogic studio, 2023)*



Carbon Eaters *(PUMA + MIT Design Lab, 2018)*

Part 1:

In part 1 the seven pathways are first presented through showing some examples and three questions that outline the type of artefacts that this pathway can be applied to. When the answer to one (or more) questions of the pathway is 'yes' then the pathway can be applied. At the end of part 1, designers should have two or three pathways in mind which they will apply to their design in part 2. If more then three pathways can be applied it is important that the designer chooses two or three out of those to continue with. Designers can of course apply the cards multiple times and create a second concept design where they apply a few other pathways.

These questions are inspired by Richardson, Dobson et al. (, 2020) who explain how to apply the pathways to nature connectedness to society. In theory these pathways can be applied to every artefact, however to create a strong design it is recommended to focus on a few aspects to change (through a few pathways) instead of trying to incorporate everything into one design. This part helps guide designers into a direction to where the artefact can have a large impact on the nature connectedness of many individuals in society.

A2. Living Aesthetics

- Does the artefact look like it is alive and living?
- How does the artifact change and evolve over time?
- How is the livingness expressed in the physical attributes to see (feel, smell, hear or taste)?

A2. Living Aesthetics

- How is the user's attention pulled towards the living characteristics of the artefact?
- How can certain livingness, that is not viewable to the human eye, be surfaced?

B2. Interactions

- How can you invite the user to interact with the living species?
- How can you make sure that people mindfully pay attention to the interaction through multiple senses?

B2. Interactions

- Should the living artefact suggest the interaction or should this be mediated by another object/medium?
- Can you let humans engage with the artefact and living species in an artistic manner?

C2. Affective Response

- How can you bring the user(s) attention towards the positive emotions that they feel due to the natural species?
- What are motivations to buy, or interact with the artefact?
- How can you create an emotional bond between the artefact and user?

C2. Affective Response

- Can people adjust the artefact to suit their needs, express themselves and develop their self concept?
- How can you show the added function for the user and/or their environment?

D2. Habitabilities

- What role do the different species and users have in maintaining a functioning first habitat (within the artefact)?
- What is needed around the artefact to help create a good habitat for the aimed at species and how can the user(s) play a role in this?

D2. Habitabilities

- How do the elements and species in the artefacts environment influence each other and the artefact?
- How does the artefact make users aware of the shared habitat for multiple species besides themselves?

E2. Care & Compassion

- Can the artefact offer a reciprical relationship with humans?
- How can the artefact elicit empathy and/ or compassion (eg. anthropomorphising)?
- How can you make the caretaking fun, easy and/or leave room for experimentation?

E2. Care & Compassion

- How can you communicate the needs & wants of the artefact/species to the caretaker(s)?
- How can you integrate the caretaking into the daily/weekly routine, and into the household/ community (eg. remind the user(s))?

F2. Views of Nature

- Can the artefact change peoples view of nature; from an anthropocentric view to a non-anthropecentric interdependance view?
- Can the artefact make humans think of the larger meaning that nature has in their life and in society?

F2. Views of Nature

- Can natural occurances, cycles and signs of life be celebrated through the (use of the) artefact?
- Do the natural species in the artefact symbolize something in nature/life?
- Is the living species used in a cultural activity to bring meaning to the life of the user(s)?

G2. Ecological Knowledge

- What ecological knowledge does the user have and which knowledge will be thought through using the artefact?
- What is important for user(s) to become aware about nature through the use of the artefact?

G2. Ecological Knowledge

- Can you let user(s) learn knowledge/ gain awareness in an interactive, fun & personal manner?
- Can you integrate the learning into the user(s) regular routine?
- How can you evoke a curious attitude towards nature via the artefact?

Part 2:

In part two, the designer will go to the pathways that they have selected in part one. The guiding questions make you think of how you can adapt your original design according to this pathway. The questions will force you to make certain aspects more concrete or to evaluate if your design already takes these aspects into account. When using the cards designers can brainstorm and draw out ideas. It can be used individually and together in creative sessions with multiple designers/ stakeholders.

These guiding questions are again based on the pathways to nature connectedness and the living artefacts framework. They are supplemented with insights from user research and other literature research. These insights include but are not limited to: evoking a curious attitude towards nature, adjusting the artefact to users needs and integrating it into the regular routine.

Algae graphs

Lia Giraud & Claude Yéprémian, 2014

Example
Living
Aesthetics

A living image is made by projecting a negative image on to a Petri dish containing a microalgae culture, and then displayed at an exhibiton. The images will continue to live and evolve in the face of the hostile conditions of the exhibition: degradation, contamination, interventions by the viewer, etc.

Relevant pathways

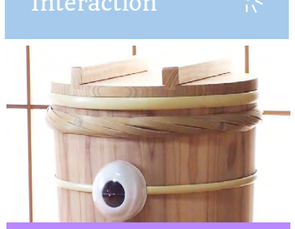
Airbubble

ecoLogic Studio, 2021

Example
Interaction

A playground using microalgae & technology to clean the air and mask urban noises. The purifying process is powered by solar energy and children's playfulness. Kids interact by jumping on four water foot pumps positioned on the ground while balancing on the bouncy bubbles and the internal rope system.

Relevant pathways



Nuka Bot

Chen. et al, 2021

Example
Affective
Response

A technologically enhanced traditional Japanese wooden bucket used to pickle vegetables using lactic acid bacteria; it is able to have conversations with humans via voice interaction. This artefact represents the user's culture and adds the function of helping remember them to care for their nukadokos.

Relevant pathways

Genesis Ecoscreen

L. Lawson, 2019

Example
Habitabilities

A fully 3D printed urban biodiversity habitat made from recycled plastics. The artefact creates a product with unique characteristics specific to its environment: with ideal placement for its plants, insect habitats, and embedded channels for water flow and drainage for the setting it will be installed in.

Relevant pathways

Flavorium

Groutars & Risseeuw et al., 2022

Example
Living
Aesthetics

The users steps per day is measured by a smartwatch and translated to the humidity level inside Flavorium. Depending on the amount of physical activity, the living monitor (with flavobacteria) will either show a rapidly expanding, brightly colored colony or one that is slowly growing and dul.

Relevant pathways

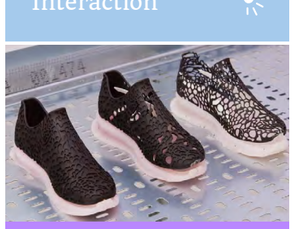
Living light lamp

Nova Innova team & Plant-e team, 2023

Example
Interaction

A lamp which harvests its energy through the photosynthetic process of the plant. The light will be activated by softly touching the plant. The available amount of energy depends on the well-being of the plant. The light created by touch will suggest further interaction.

Relevant pathways



Breathing shoe

PUMA & the Fraunhofer Institute, 2019

Example
Affective
Response

A shoe where microorganisms remove material based on the user's sweat and heat, creating a personal ventilation pattern. The shoe responds to the needs of the user, and the user helps the microorganisms to complete the last manufacturing step of the shoe and its functionality.

Relevant pathways

Biogarmentry

Roya Aghighi, 2019

Example
Habitabilities

A biotextile that lives through photosynthesis, removing toxins in the air. The textile is dependent on its user for optimal growth and health, fundamentally challenging our current relationship to our clothes. Care is needed from the user to maintain a suitable habitat for the microorganisms in and around the textile.

Relevant pathways

Living wall

D. Briscoe, 2018

Example
Care &
Compassion

A living wall that serves as a bio-habitat. The native plants were chosen to attract and provide shelter for many animal species. After installation a building information modelling workflow is used to monitor the biological species, therefore making the caring experience easier and more interactive.

Relevant pathways

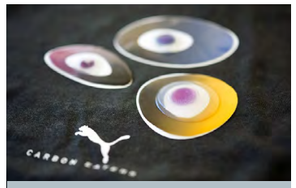
Living Coccoon

Loop-biotech, 2023

Example
Views of
Nature

A living coffin made from mycelium that allows human to become part of the natural cycle of life and enrich nature. This artefact celebrates the cycles of nature and adds meaning to the end of life of humans and their loved ones.

Relevant pathways



Carbon Eaters

PUMA + MIT Design Lab, 2018

Example
Ecological
Knowledge

A t-shirt with microbially-activated stickers that respond to the CO2 in the environment by changing color to inform users about the quality of air around them. The awareness of air quality is integrated into the users daily run in a fun manner.

Relevant pathways

Slime mould watch

Lu & Lopez, 2022

Example
Care &
Compassion

A smartwatch with a slime mold that conducts power to a heart rate sensor, creating a living wire. The sensing depends on the health of the mold—with care, the mold becomes conductive and enables the sensor; without care, the mold dries and disables the sensor (resuming care resuscitates the slime mold).

Relevant pathways

Urban Algae Canopy

ecoLogic Studio, 2015

Example
Views of
Nature

The transparency, color and shading potential of the canopy is the product of the interrelationships between climate, micro-algae, visitors and digital control systems. The canopy shows the meaning of micro-algae in our life and the interdependencies of nature, humans and technology in our society.

Relevant pathways

Bio.Bolla

ecoLogic studio, 2023

Example
Ecological
Knowledge

A biotechnological interactive furniture that enables haptic stimulation. The furniture brings to both employees and visitors of the hospital a valuable educational experience learning about microalgae through the power of observation, play and interaction.

Relevant pathways

Examples:

In order to get a feel for what kind of artefacts can possibly contribute to a high nature connectedness example cards are included. For each pathway there are two main examples, however multiple pathways can be applied to one design, so all the (most) relevant pathways are shown on the back side of each card.

There is a lot of overlap between the pathways and these examples are just one categorisation to serve as inspiration and context setters.

8. Design Iterations of Design Guidelines

Based on literature research, exploratory research, and citizen research, the process of ideating guidelines for nature connectedness commenced. The initial framework utilized as a foundation was the “5 pathways to nature connectedness” proposed by Richardson, Dobson et al. (2020). This framework was then adapted to align with the living artifacts framework developed by Karana, Barati et al. (2020), while also incorporating and supplementing it with findings from the various research conducted. As a result, an initial version of the guidelines for enhancing human-nature connectedness through living artifacts was established.

To further refine the guidelines, feedback was sought from two established bio-designers, which led to the creation of a second version in the form of a card set. This card set was subjected to evaluation by another design student who had no prior knowledge of living artifacts but expressed an interest in exploring the topic for their graduation assignment. The insights gained from this evaluation process were instrumental in finalizing the card set, which was presented in the preceding Chapter as the ultimate version of the guidelines.

First Concept Design

Based on the research, brainstorming for guidelines began. Initial sketches were made (Appendix I), and the most promising questions were selected. The wording was refined, and visual examples of living artifacts were added for reference and inspiration.

To improve usability, the guidelines were divided into two parts, providing clearer guidance on incorporating the pathways into designs. This enables users to create impactful designs with societal implications, following the proposed application by Richardson, Dobson et al. (2020).

Design Guidelines - Adapting living artefacts to increase human-nature connectedness

Sensorial Contact	Emotions	Beauty	Cultural Meaning	Compassion
Is it part of the urban landscape/housing?	Does it help create a space that represents a natural environment?	Is it an art installation?	Is it a cultural object?	Does the artefact require care?
Is it an art installation?	Can people easily attach an emotional connection to it?	Can people interact with it in an artistic way (painting it)?	Does the artefact symbolize a larger meaning?	Does the artefact support local (urban) wild life?
Does it require interaction from the user?	Can it be shared with loved ones?	Does it contain natural shapes and colors?	Can the artefact be used in common rituals or traditions?	Are there several natural species at play interacting with each other?
Is it meant to be observed closely (with the senses)	Can it help create positive memories?	Is it a fashionable object?	Is the artefact part of the daily life of the user, does it fulfill an important function, represent important values?	Can the user(s) create a caring connection with the artefact?

If the answer is yes then you can apply the pathway to your artefact.
Choose one or two (of the above) pathways <u>to focus on</u> when adapting the living artefact.
You can add the knowledge pathway only in combination with at least one other pathway.

Knowledge

Can the artefact learn the user(s) something about nature?

Is there different pre-existing knowledge about the artefact/ natural attributes that can affect the use of the artefact?

Can the artefact play a role in education?

Sensorial Contact

What kind of natural attributes can be sensed by the user(s) (through: sight, touch, smell, sound)?

How is the attention of the user(s) pulled towards the sensorial natural attributes of the artefact?

How can you make sure that people will take a moment to really consciously notice the natural atributes?

How can you invite the user to interact with the natural attributes with their senses (through: sight, touch, smell, sound)?

Example activities to add:
Care Taking, Touching, Smelling, Listening, Mindfullness, Photographing.

Example of living artefacts with sensorial contact

Living walls

Living light

Emotions

How does this artefact and the natural attributes elicit emotions in the user(s)?

Which positive & negative emotions can arise?

How can you bring the attention of the user(s) towards the positive emotions that they feel due to the natural attributes?

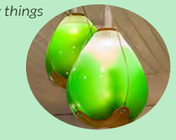
Can you have the user(s) formulate and list the positive emotions that they feel?

Can the user(s) share these positive emotions with their loved ones and create hapy memories with the living artefact?

Example activities to add:
Mindfullness, Listing Emotions, Smilling, Observing the artefact over time.

Example of living artefacts with emotional attachement

Living things



H.O.R.T.U.S. XL

Beauty

What can be interpreted as beautiful about the living artefact and the natural attributes of it?

Does the artifact have a natural beauty that you cannot see but that you can feel, hear or smell?

How is the user's attention pulled towards the beautiful natural aspects of the artefact?

Does the living artefact look like a it is alive and living?

Can the user(s) interact in an artisitic way with the natural elements of the living artefact?

Example activities to add:
Photographing, Videographing, Painting, Making a poem, sculpting.

Example of living artefacts with beautiful aspect

Genesis EcoScreen

Algae Graphs

Cultural Meaning

Does the artefact make people think of the larger meaning that nature has in their life and in society?

Does the natural element in the artefact symbolize something else in nature or in the user's life?

Is the artefact used in a common activity, tradition, ritual that has any connection to nature?

Is the artefact shared by loved ones or a community?

Does the artefact celebrate natural occurances?

Example activities to add:
Documentary/film about the artefact, Festival, Family activity, Reflecting.

Example of living artefacts with cultural meaning

Urban Algae Canopy

Airbubble Algae playground

Compassion

What is the minimum and maximum care required for the artefact?

Who are the care takers of the artefact and what are their motivations for taking care of it?

How much freedom does the user have to experiment with different methods of caretaking?

Can people take care of it together with loved ones, neighbours or other liked minded individuals?

Is there a way that they are regurarly (daily/weekly) reminded to take care of it, that can be integrated into their routine?

Example of activities to add:
Give Water/Nutrients, Regulate Temp./Humidity, Give Love & Attention

Example of living artefacts with compassional care

Biogarmentry

Living walls

Knowledge

What knowledge does the user(s) have about the artefact and the nature on it?

What is most important for the user to learn or become aware of about nature through the living artefact?

Can you let the user(s) learn the above set information/lesson in an interactive and playfull mannor?

Can you integrate the learning into the user(s) daily/weekly routine ?

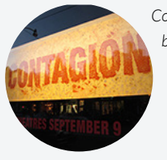
Can you make the activity fun & personal?

Example of activities to add:
Citizen science, Educational course/game, Interactive Educational Walk.

Example of living artefacts with knowledge activity

Carbon Eaters

Contagion billboard



Evaluation session with experienced Biodesigners

After completing the initial concept design, it was time to proceed with another design iteration. Following a brief period of reflection, I conducted a personal evaluation, which led me to make a few decisions. Among other things, I decided to remove the activities and instead expand on the examples, as they provide more illustrative and inspirational content.

Furthermore, evaluation sessions were conducted for both Part 1 and Part 2 of the design cards. Part 1 was reviewed by Raphael Kim, a postdoctoral researcher and designer specializing in bio-technology within the field of Human-Computer Interaction (HCI) at the Materials Experience Lab, TU Delft. Part 2 was reviewed by Elvin Karana, a Professor of Materials Innovation and Design at the Faculty of Industrial Design Engineering (TU Delft), with a focus on bio-based materials and bio-technology for product design.

Main Insights

Figure 26 provides an overview of the evaluation sessions, and the main insights gained from these evaluations are as follows:

- Give clarification on intended user and how to use.
- Changing of wording categories and questions.
- Extra category 'Habitabilities'.
- Part 1: Limiting it to three questions.
- Part 2: Re-order certain questions to another category.
- Create an order in the categories and questions.
- Include some other examples and tell more about them.

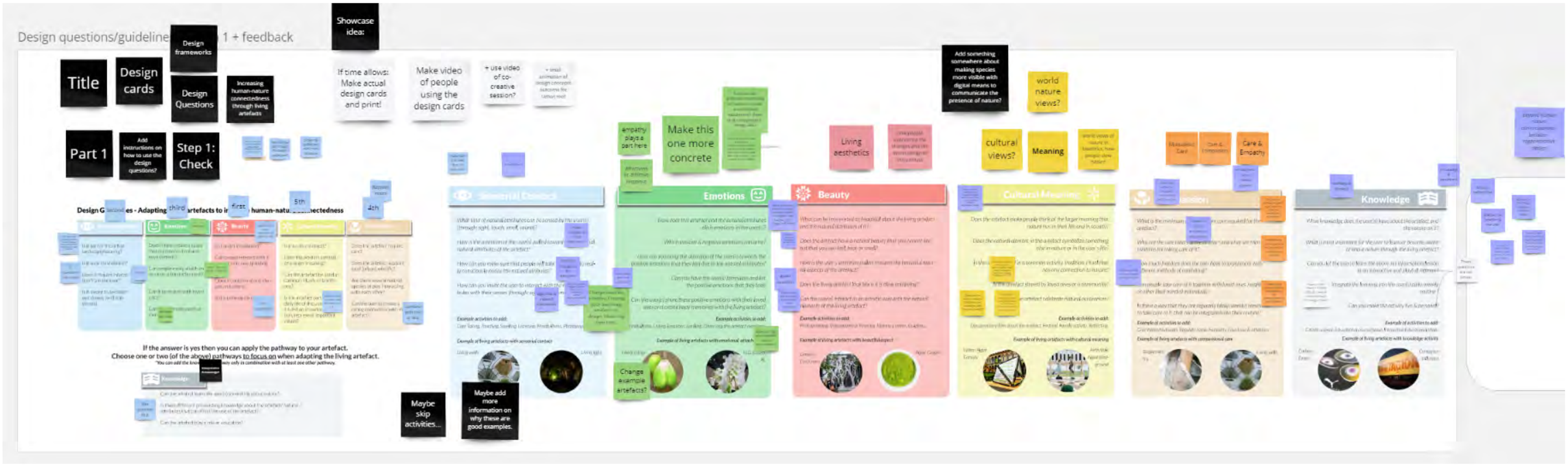


Figure 26. Overview of evaluation sessions with biodesigners

Second Concept Design

After the evaluation sessions with experienced bio-designers, it was decided to change the lay-out of the guidelines from a simple few pages to a more elaborate card set which designers could hold in the hand as part of creative brainstorm sessions. These cards were partly inspired by the more-than-human design cards made by Daniel Metcalfe as part of his PhD research (Metcalfe, 2015). All of the main insights from the previous evaluation were taken into account and some lay-out changes were made to fit the new card style.

This resulted in the following Second Concept Design shown below.

The main changes compared to Concept Design one are:
- Card set, front and back
- Made shorter and concreter
- Changed wording and order
- Changed lay-out
- Activities were excluded
- Added more information on examples of Living Artefacts
- Re-evaluated the categorisation of living artefacts

Introduction card:
Explanation on goal and use of cards.

Human-Nature Connectedness through Living Artefacts

Design Guidelines

These are design guidelines for designers of living artefacts to create & adapt designs to allow for a high human-nature connectedness. You can repeatedly apply the design cards throughout your design process to your design ideas, concepts & prototype(s).

Part 1: If the answer is yes to one or more questions, then you can apply the pathway. It is recommended to choose two to three pathways to focus on in creating a strong design. It can however be possible to apply all of the pathways.

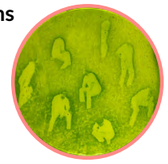
Part 2: Select the pathways chosen in part one. Use the guiding questions to create and adapt your design(s), and view the examples on the back.

Made by Dawn Verkerk

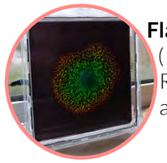
1A. Living Aesthethics

- **Does the artefact contain natural charecteristics (shapes & colors etc)?**
- **Is it an artistic artefact?**
- **Is it a wearable object?**

Examples Living Artefacts



Algae graphs (Lia Giraud & Claude Yéprémian, 2014)



Flavorium (Groutars & Risseeuw et al., 2022)

1B. Interactions

- **Is there space for (artistic) interaction?**
- **Is it part of the urban landscape?**
- **Is it meant to be observed closely?**

Examples of Living Artefacts

Airbubble *(ecoLogic Studio, 2021)*

Living light lamp (Nova Innova team & Plant-e team, 2023)

1C. Affective Response

- **Does the artefact help create a space that represents a natural environment?**
- **Is there possibility for people to create an emotional attachement to it?**
- **Can the artefact be shared by loved ones or a community?**

Examples of Living Artefacts

Puma breathing shoe *(PUMA & the Fraunhofer Institute, 2019)*

Nuka Bot *(Chen. et al, 2021)*

Part 1:
Questions that bring focus and introduce the topics and examples of the pathways.

1D. Habitabilities

- **Are humans important to create a suitable habitat for the artefact?**
- **Are there multiple species interacting with each other?**
- **Does the artfact have a large effect on the local eco-system?**

Examples of Living Artefacts

Biogarmentry (Roya Aghighi, 2019)

Genesis Ecoscreen (L. Lawson, 2019)

1E. Care & Compassion

- **Does the artefact require (external) care to stay alive?**
- **Does the artefact support local (urban) wild life?**
- **Can the artefact elicit a feeling of compassion?**

Examples of Living Artefacts

Slime mould watch (Lu & Lopez, 2022)

Living wall (D. Briscoe, 2018)

1F. Views of Nature

- **Is it a cultural artefact?**
- **Does the artefact symbolize a larger meaning?**
- **Can the artefact be used in common rituals, traditions or routines?**

Examples of Living Artefacts

Urban Algae Canopy *(ecoLogic Studio, 2015)*

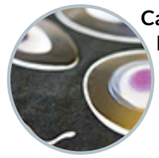
Living Coccoon *(Loop-biotech, 2023)*

1G. Ecological Knowledge

- **Does the level of pre-existing knowledge about ecology affect the use of the artefact?**
- **Can the user(s) learn something about ecology through the use of the artefact?**
- **Can the artefact play a role in education?**

Examples of Living Artefacts

Bio.Bolla *(ecoLogic studio, 2023)*



Carbon Eaters *(PUMA + MIT Design Lab, 2018)*

2A. Living Aesthethics

- **Does the artefact look like it is alive and living?**
- **How does the artifact change and evolve over time?**
- **How is the livingness expressed in the physical attributes to see, feel, smell or hear?**

Example

Algae graphs (Lia Giraud & Claude Yéprémian, 2014) A living image is made by projecting a negative image on to a Petri dish containing a microalgae culture, and then displayed at an exhibiton. The images will continue to live and evolve in the face of the hostile conditions of the exhibition: degradation, contamination, interventions by the viewer, etc.

2B. Interactions

- **Should the living artefact suggest the interaction or should this be mediated by another object/medium?**

Example

Living light lamp (Nova Innova team & Plant-e team, 2023)
A lamp which harvests its energy through the photo-synthetic process of the plant. The light will be activated by softly touching the plant. The available amount of energy depends on the well-being of the plant. The light created by touch will suggest further interaction.

2C. Affective Response

- **How can you bring the attention of the user(s) towards the positive emotions that they feel due to the natural species?**
- **What are the personal motivations for users to buy, interact or take care of the artefact?**

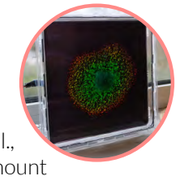
Example

Puma breathing shoe *(PUMA & the Fraunhofer Institute, 2019)*
A shoe where microorganisms remove material based on the user's sweat and heat, creating a personal ventilation pattern. The shoe responds to the needs of the user, and the user helps the microorganisms to complete the last manufacturing step of the shoe and its functionality.

2A. Living Aesthethics

- **How is the user's attention pulled towards the living charecteristics of the artefact?**
- **How can certain not noticable livingness be surfaced?**

Example



Flavorium (Groutars & Risseeuw et al., 2022) The amount of steps per day measured by a smartwatch is translated to the humidity level inside Flavorium. Depending on the amount of physical activity measured by the smartwatch, the living monitor (with flavobacteria) will either show a rapidly expanding, brightly colored colony or one that is slowly growing and dul.

2B. Interactions

- **How can you invite the user to interact with the living species with their senses (through: sight, touch, smell, sound)?**
- **How can you make sure that people mindfully pay attention to the interaction via their senses?**

Example

Airbubble *(ecoLogic Studio, 2021)*
A playground using micro-algae & technology to clean the air and mask urban noises. The purifying process is powered by solar energy and children's playfulness. Kids can interact by jumping on four water foot pumps positioned on the ground while balancing on the bouncy bubbles and the internal rope system.

2C. Affective Response

- **Can people adjust the artefact to suit their needs, express themselves and develop their self concept?**
- **How can you show the added function for the user and/or their environment?**

Example

Nuka Bot *(Chen. et al, 2021)*A technologically enhanced traditional Japanese wooden bucket used to pickle vegetables using lactic acid bacteria; it is able to have conversations with humans via voice interaction. This artefact represents the user's culture and adds the function of helping remember them to care for their nukadokos.

2D. Habitabilities

- **What role do the different species and users have in maintaining a functioning first habitat (within the artefact)?**
- **What is needed around the artefact to help create a good habitat for the aimed at species and how can the user(s) play a role in this?**

Example

Biogarmentry (Roya Aghighi, 2019)
A biotextile that lives through photosynthesis, removing toxins in our air. The textile is dependent on its user for optimal growth and health, fundamentally challenging our current relationship to our clothes. Care is needed from the user to maintain a good habitat for the microorganisms in and around the living textile.

2D. Habitabilities

- **How do the elements and species in the artefacts environment influence each other and the artefact?**
- **How does the artefact make users aware of the shared habitat for multiple species besides themselves?**

Example

Genesis Ecoscreen (L. Lawson, 2019) A fully 3D printed urban biodiversity habitat made from recycled plastics. The artefact creates a product with unique characteristics specific to its environment: with ideal placement for its plants, insect habitats, and embedded channels for water flow and drainage for the setting it will be installed in.

2E. Care & Compassion

- **How can you communicate the needs & wants of the artefact/species to the caretaker(s)?**
- **How can you integrate the caretaking into the daily/weekly routine, and into the household/ community (eg. remind the user(s))?**

Example

Living wall (D. Briscoe, 2018)
A living wall that serves as a bio-habitat. The carefully-selected native plants were chosen to attract and provide shelter for many animal species. After instal-lation a building information modelling workflow is used to monitor the biological species, therefore making the caring experience easier and more interactive.

Part 2 (1/2):
Guiding questions that prompt designers to think of the different aspects of their design and develop them further. Accompanied by examples that give an example of how the pathway can be incorporated in a living artefact.

2E. Care & Compassion

- **Can the artefact offer a reciprical relationship with humans?**
- **How can the artefact elicit empathy and/ or compassion (eg. anthropomorphising)?**
- **How can you make the caretaking fun, easy and/or leave room for experimentation?**

Example

Slime mould watch (Lu & Lopez, 2022)
A smartwatch with a slime mold that conducts power to a heart rate sensor, creating a living wire. The sensing depends on the health of the slime mold—with care, the slime mold becomes conductive and enables the sensor; without care, the slime mold dries and disables the sensor (resuming care resuscitates the slime mold).

2F. Views of Nature

- **Can the artefact change peoples view of nature; from a devaluation anthropocentric view to a valuation non-anthropecentric view?**
- **Can the artefact make humans think of the larger meaning that nature has in their life and in society?**

Example

Urban Algae Canopy *(eco-Logic Studio, 2015)*
The transparency, color and shading potential of the canopy is the product of the interrelationships between climate, micro-algae, visitors and digital control systems. The canopy shows the meaning of micro-algae in our life and the interdependencies of nature, humans and technology in our society.

2F. Views of Nature

- **Can natural occurances, cycles and signs of life be celebrated through the (use of the) artefact?**
- **Do the natural species in the artefact symbolize something in nature/life?**
- **Is the living species used in a cultural activity to bring meaning to the life of the user(s)?**

Example

Living Coccoon *(Loop-biotech, 2023)*
A living coffin made from mycelium that allows human to become part of the natural cycle of life and enrich nature. This artefact celebrates the cycles of nature and adds meaning to the end of life of humans and their loved ones.

2G. Ecological Knowledge

- **What ecological knowledge does the user user have and which knowledge will be thought through using the artefact?**
- **What is important for user(s) to become aware about nature through the use of the artefact?**

Example

Bio.Bolla *(ecoLogic studio, 2023)* A biotechnological interactive furniture that enables haptic stimulation. The furniture brings to both employees and visitors of the hospital a valuable educational experience learning about microalgae through the power of observation, play and interaction.

2G. Ecological Knowledge

- **Can you let user(s) learn knowledge/ gain awareness in an interactive, fun & personal manner?**
- **Can you integrate the learning into the user(s) regular routine?**
- **How can you evoke a curious attitude towards nature via the artefact?**

Example

Carbon Eaters *(PUMA + MIT Design Lab, 2018)*
A t-shirt with microbially-activated stickers that respond to the CO2 in the environment by changing color to inform users about the quality of air around them. The awareness of air quality is integrated into the users daily run in a fun manner.

Part 2 (2/2):

Guiding questions that prompt designers to think of the different aspects of their design and develop them further. Accompanied by examples that give an example of how the pathway can be incorporated in a living artefact.

Final Evaluation with design student

A quick prototype of the design cards was made by printing the design cards next to each other on A3. With this prototype an evaluation of the cards was held with a design student from the Master Integrated Product Design who had no previous knowledge of Living Artefacts. A short explanation was given about the topic of Living Artefacts and it was asked that the student had an original idea (starting point) of a type of living artefact it could design. The starting point was: a temporary bus stop that had a living element, eg. an ant wall, that could change over time (Top of Figure 27). After the starting point was established, the student was handed the prototype of the cards and asked to think out loud and sketch and/or write ideas and thought however they found necessary to develop his idea.

During the session, the design student made several notes and some quick drawings (Figure 27). One of the outcomes of the session was: A wall with algae and light where users can move the light around (to influence the microalgae growth) and other users can see the effect on the microalgae by the people that interacted with the wall before them.

The main insights from this user evaluation were:
- Part 1 worked well to give focus and minimize the amount of time spent brainstorming with the cards.
- Part 2 helped him reflect, think of more ideas and also prompted more design questions.
- Change visual lay-out of Part 1 opposed to Part 2.
- Change a few coloured backgrounds to increase readability.
- Change examples to be separate cards (that can be held in the hand on the side) instead of on the back.
- Change spelling and wording of certain questions.

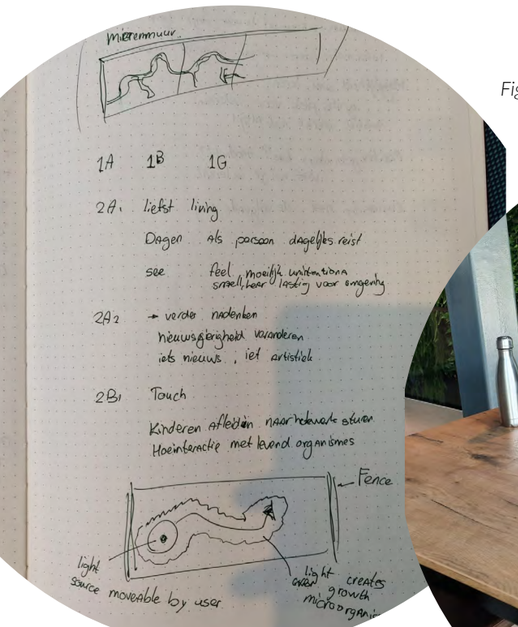


Figure 27. Notes and sketches user evaluation

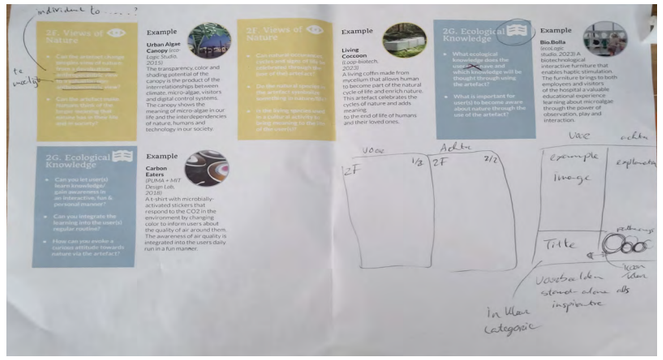
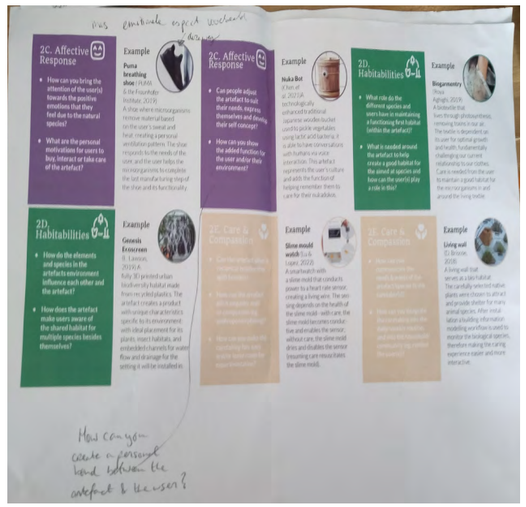


Figure 28. Overview of sketches during user evaluation



9. Concept Design & User Evaluation

To demonstrate in which way the design guidelines from the previous Chapter can be applied to a living artefact the guidelines have been applied to the existing prototypes of Urban Reef. The guidelines were applied three times resulting in three concept designs, for each concept design different pathways were applied. The way that these concepts are presented it can in this case be possible to make one concept design where all three concepts are integrated into one design. However like mentioned before the design of the artefact has the potential to be stronger if it has a focus on a few adaptations instead of many adaptations at once, therefore it is chosen to keep them separate.

Additionally these adaptations could be evaluated separately by possible users. In this Chapter the three concepts will be explained and the Chapter will close of with an evaluation of the concepts by possible users. Based on the concept designs and the evaluation some recommendations for Urban Reef will be mentioned in the following Chapter.

Concept A:

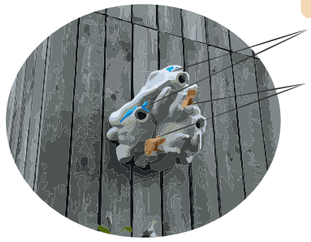
Concept A was ideated by applying the pathways: Care & Compassion, Living Aesthetics and Interaction. This resulted in an alteration of the prototype design of the Sparrow Reef that Urban Reef has recently created and is testing. This reef has the most potential to add functional interaction by the users. Users can order care packages with the reef which includes, food for sparrows and plants for around the reef as well as a care taking dairy. Through visual indications in colour and shape it is made clear where users can place food for the sparrows on the reef, or where to add fresh water for the birds at times of a dry climate. To ensure that it is integrated into the regular routine of the users and they take the time to really connect to the nature in and around the reef a caretaking dairy is added. This dairy can be hung in the kitchen or living room on a clearly viewable place where the whole household can view it.

Concept B:

Concept B was ideated by applying the pathways: Care & Compassion and Affective Response. This resulted in a concept design where users could create their very own personal reef based on their wishes and needs. Users will start by inputting some requirements, based on this they will get a few options of reef that fit those requirements. Next they can view how the reef can look in their garden through using VR and lastly edit some details (colour and plateaus) about the reef to increase personalisation.In this way users will create a reef that they feel fits their house and their personal ambitions as well as aesthetics.

This has the potential to create a more deeper bond between the user and the reef because it is completely personalized to each user.

The Reef, the Sparrows and Me



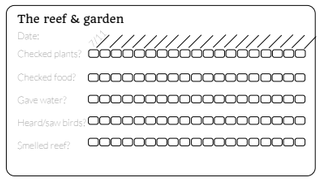
Spaces to add water (if necessary)

Pockets to place food for sparrow

Suggestion to let places in garden go wild or plant wild species for birds around the reef

Order care packages and help kick-start the reef

Keep a care diary in kitchen/living room



Guidelines applied

Care & Compassion

Interaction

Living Aesthetic

1. With this sparrow reef you can order a care package: containing plants seeds, food and tips to help you create a suitable habitat for sparrows in your garden.
2. Additionally you can select a physical or online diary where you can track (together with your family/housemates) when you took care of the reef.
3. Over time you will see your reef and garden develop and hopefully sparrows (and more species) will visit your garden once in a while for you to enjoy their beautiful songs.

My Very Own Reef

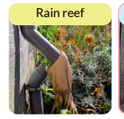
Put in wishes for personalisation

Maximum Size (w x d x h) 20 x 30 x 60 cm

Biodiversity Impact: Medium (Low, Medium, High)

Added Personal Function: Cooling (Shading, Cooling, Collect Rainwater)

Choose a type of reef



Adapt reef to garden with VR

Change color

Guidelines applied

Care & Compassion

Affective Response

1. You can put in your personal wishes so that you can find a reef that fits your outdoor space (garden, balcony, roofterrace) and personal preferences.
2. Based on your preferences some options are shown that are aimed at different habitats/species. You can choose a reef that that you like the most for your outdoor space.
3. Then you can upload one (or more) pictures of your garden/balcony/roof terrace. By using VR you can move the reef around in the picture, add more bulges/plateas and change the color.

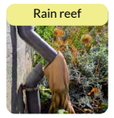
Concept C:

Concept C was ideated by applying the pathways: Care & Compassion, Views of Nature and Ecological Knowledge. This resulted in a concept design where users can add a citizen science package to their purchased reef, this package can allow for a discount on the added reef. In this package certain sensors are added which allow users to closely monitor the conditions around the reef. Users will agree to monitor the progress of the reef every 2 weeks by measuring the local environmental conditions and uploading pictures of the reef on iNaturlist (and the natural species on it). Through this way Urban Reef will get insights in which conditions work best for the reef and learn more about the species that are attracted by the reefs. Additionally, the users will also learn more about nature and play close attention to the different species in their garden. Lastly, a community will be built through the discussing of results between users via the iNaturalist platform and through getting participants together a few times per year to discuss and celebrate the nature in everyone's gardens.

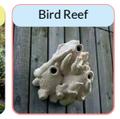
A Community Researching the Reef

Choose a type of reef

Rain reef



Bird Reef



Pond Reef

Add citizen science package

Receive small sensors (temperature, light, humidity etc) an download sensor app.

Grow a community

1. Monitor the reef via iNaturalist.
2. Share your results with fellow urban reef users, researchers and more interested people.
3. Discuss your observations together.

Guidelines applied

Care & Compassion

Views of Nature

Ecological Knowledge

1. First you can choose a Reef and size according to your whishes.
2. Then you additionally order the citizen science package (for a small price) that gives you a 10% discount on the price of the reef.
   A. When you buy this package you agree to monitor progress every 2 weeks via iNaturalist with pictures and measurements (Urban Reef will send reminders, and come visit every few months).
   B. Next to that you can share & discuss results with other "reef scientists" on the iNaturalist platform.
3. Urban Reef will organize special events once or twice a year to bring everyone together: during these events everyone can discuss and celebrate the nature in our gardens!

User Evaluation of Concepts

Previously 3 concepts are shown which have the potential to increase the nature connectedness of the user. However in order to reach these users it is essential for Urban Reef that these reefs/ services are attractive to potential customers to buy. Therefore a survey was conducted to gain input from users on the attractiveness of the concepts and possible changes that are needed to make these reefs/services more attractive. The method of a survey was chosen in order to reach more potential customers and retrieve more insights. During the survey some personal questions were asked about age, gender, household and income. Secondly, several open questions were asked about the participants opinion of each concept. The survey closed of with questions on the preferred concept and the price they would pay for it. For the complete survey see Appendix K.

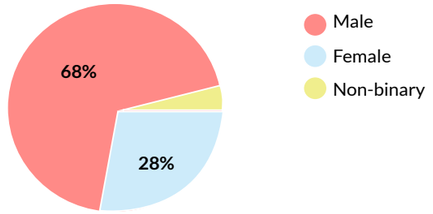


Figure 30. Division gender survey

Audience of survey

The survey had a total of 25 participants with an age between 23 and 78 years old (for age division see Figure 28). Of the 25 participants:17 identified as female, 8 as male and 1 as non-binary (Figure 29). Almost all participant had some kind of outdoor space, most had a balcony (15 participants) and a few had a garden (8 participants) and/or roof terrace (5 participants), Figure 30. There were three participants that had more then one kind of personal outdoor space. The participants lived in different types of households as can be seen in Figure 31. A total of 10 participants shared the yearly income of their household, the yearly income ranged from 20.000 to 60.000 euro per year, the median income was 31.200 euro per year.

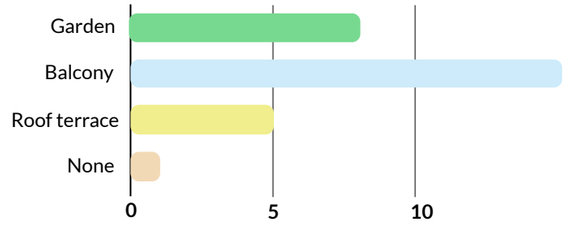


Figure 31. Tyoe of outdoorspace available

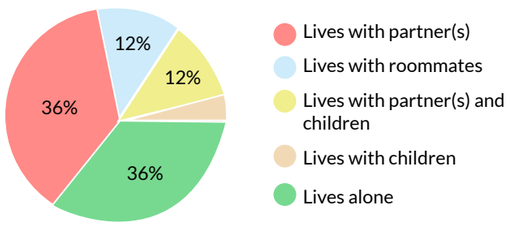


Figure 32. Household division

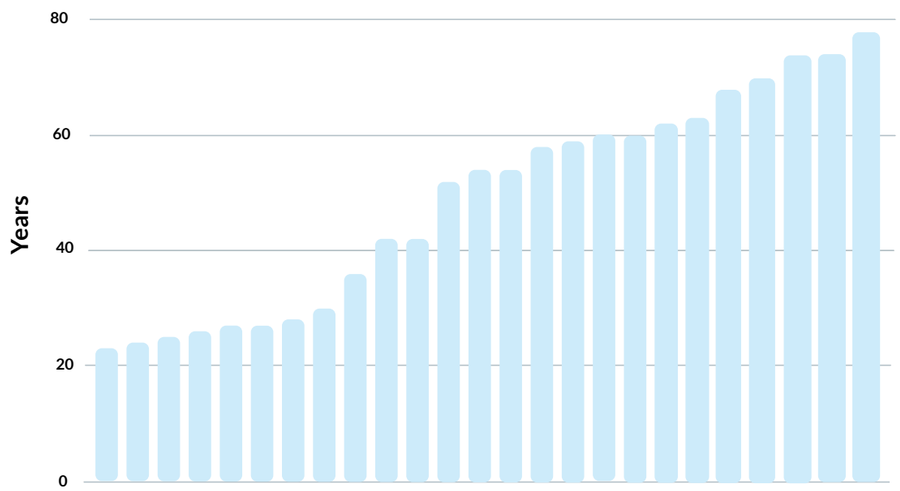


Figure 29. Age division survey

Results of survey

From the survey it was shown that most participants preferred concept B over the other concepts (Figure 32). There is some interest in Concept A and C, however this is a more limited smaller target group. Some participants even mentioned they would like a combination of Concept A and B or a combination of concept B and Concept C. The reasons mentioned for preferring Concept B was mostly due to the freedom of choice and the helping of thinking what is best for their home. Some participants mention that they think Concept A and C will take too much time effort and Concept B requires the least amount of time after purchasirg. When asked about the emotions (see Figure 33) that the participant felt with each concept it was clearly shown that the most people felt joy, fascination and hope with Concept B. There was the most curiosity however towards Concept A. On the other hand, many participants (7) felt distrust and apathetic towards Concept C. Additionally many participants mentioned that it was not clear enough what the goal of the research would be of the citizen science from Concept C. On the other hand even though a few participants had questions about Concept A many participants found this concept the most simple and clear.

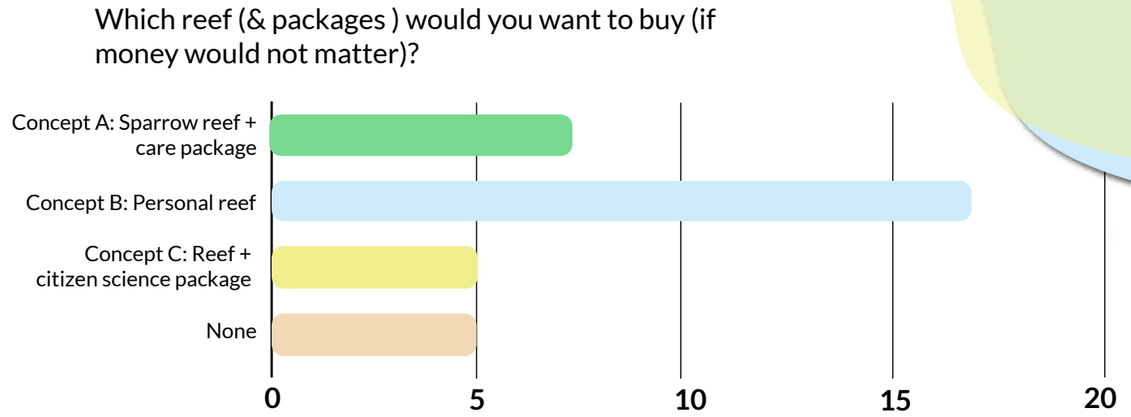


Figure 33. *Preferance of Concept (multiple could be selected)*

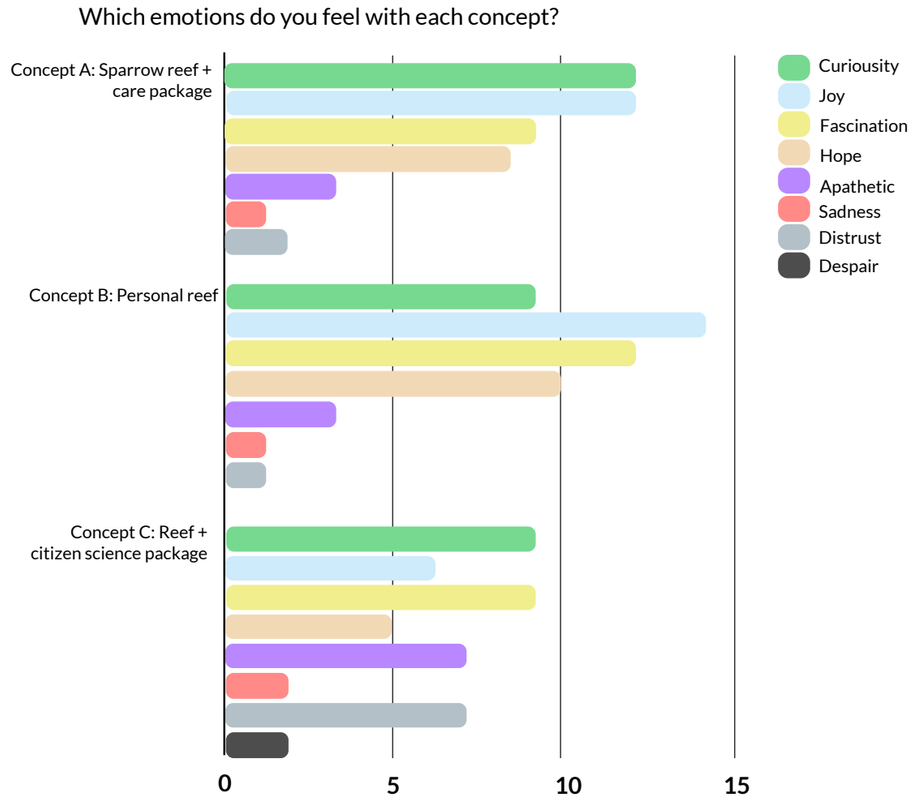
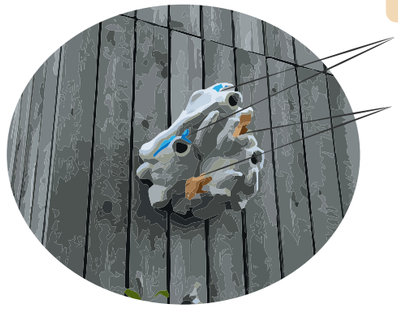


Figure 34. *Amount of participants that felt these emotions at each concept*

The Reef, the Sparrows and Me



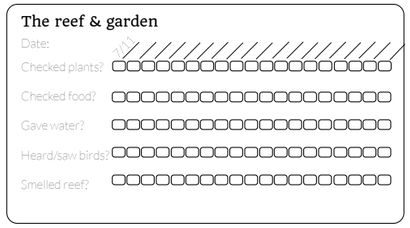
Order care packages and help kick-start the reef

Spaces to add water (if necessary)

Pockets to place food for sparrow

Suggestion to let places in garden go wild or plant wild species for birds around the reef

Keep a care diary in kitchen/living room



My Very Own Reef

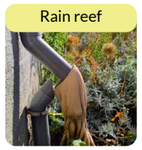
Put in wishes for personalisation

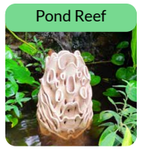
Maximum Size (w x d x h) 20 x 30 x 60 cm

Biodiversity Impact: Medium (Low, Medium, High)

Added Personal Function: Cooling (Shading, Cooling, Collect Rainwater)

Choose a type of reef



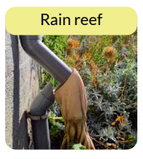


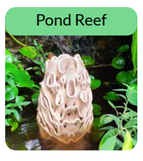
Adapt reef to garden with VR

Change color

A Community Researching the Reef

Choose a type of reef





Add citizen science package

Receive small sensors (temperature, light, humidity etc) an download sensor app.

Grow a community

1. Monitor the reef via iNaturalist.
2. Share your results with fellow urban reef users, researchers and more interested people.
3. Discuss your observations together.

Best Concept: B

Overall it can be concluded that Concept B is the most desirable for potential users. Most participants mentioned that they would spend max 100 euros on a Reef and would spend an additional of max 50 euros more for personalisation (see Appendix J for the results). Below a summarization of all the aspects that people like or dislike about the concept are given together with possible improvements.

Participants mainly like about Concept B:

- That you can adapt and choose your reef (having 3 options to choose from).
- Making something that is really personal.
- That you can adapt it to your garden and the placement of sun.
- Flexibility in use and easy to give it as a present.
- Getting an impression with VR if it will fit in the garden.

What participants don't like about Concept B:

- Too vague, need more specific function or added value.
- Hard to imagine VR part, and seems unnecessary
- Sounds too advanced/complex.
- Wondering if it is going to be worth extra costs.

Wat can be improved about Concept B:

- Seeing advice on where to place them and how far apart from each other(Ecological advice from experts)
- Making it less complex, as easy as possible
- Making it modular
- If you can place it on balcony railing or balcony wall
- Also place for personal contact (a meeting/ community) not just digital.
- See the amount of effort required, the price and the benefits per reef/system.
- Purchasing X number of different reefs as a neighbourhood for a package price, to encourage biodiversity throughout the neighbourhood. Mutually learn from each other in terms of placement, maintenance, etc.
- Is it like virtual claying or like sliders? – Would prefer virtual claying.

Concept A

Overall many participants are also very interested in Concept A. However not in the dairy part, this seems as too much work for some participants. Additionally the shape and details of Concept A need to be changed so that it would fit better in the habitat of Sparrows, so for example more like an additional reef that is for food and not for nesting. The nesting reef would be separate. Some aspects of this reef and the care package could be possibly added to Concept B.

What participants like about Concept A:

- Having birds in garden/ close to home.
- Interactive/ able to help nature in the city.
- Compact and easy to maintain.
- Interesting shape.
- Spending more time with nature/ in your garden.
- Also having an online dairy.
- Having plants and birds in the garden/balcony. Bringing nature closer to people.

What participants don't like about Concept A:

- Too much work to keep dairy.
- Some find sparrow reef not attractive for their balcony.
- Is this good for sparrows? They usually get their food somewhere else and this also attracts pests. Also the water attracts mosquitos.

What can be improved about Concept A:

- Can it contribute to a larger goal of 'natuurmonumenten'?
- Can it be incorporated into (green) garden fence?
- Could be nice with kids or elderly because it is interactive.
- Should be openable so you can take the waste of previous birds out and improve durability.
- I would expand the questions more/ create a manual. For example about the species, gender, age, breeding etc. And this can then be reported on such as waarneming.nl, so that nature organisations can benefit from it.

Concept C

Overall Concept C is the least attractive for the participants of the survey. However there is a small group (5 out of 25) that is interested in the citizen science package. Most of these participants (4 out of 5) would however want to combine Concept C with only Concept B or with both B and A. Many participants have many questions with this concept, therefore in order to make this attractive it is important to clearly state the goal of the research, the added benefit for the users and the added benefit for science/Urban Reef.

What participants like about Concept C

- That it contributes to science/nature. Connection between citizens and science, Crowdsourcing research.
- That you can be part of a larger whole of a community.
- Stimulates involvement with nature. People in the city will be more involved with nature. Creating awareness.
- Approachable way to engage with the science behind the reef. Also, the social interaction through the app and engagement from Urban Reef gives users the opportunity to spar with people on a topic you both find interesting. In addition, also celebrate nature as already mentioned.
- Consistency of research can ensure that you stay engaged with nature and your reef, which is also a kind of mindful activity.

What participants don't like about Concept C:

- Too much work, too technical.
- Probably only for a small target group.
- Mandatory monitoring, receiving visits or getting messages from an app would put me off.

What can be improved about Concept C

- Having a research report after a while. Maybe that it contributes to the research of natuurmonumenten.
- More in public/ communal spaces, for youth groups etc.
- I want to share my data of the reef with other scientist not with other users.
- Different people value different levels of interaction.
- So the option of having more automatic sensors as more analogue sensors could get more people active.
- I would like to see the statistics collected.

Conclusion

What is clear from the responses is that many people have a different view of nature in the city and what the role is of citizens to improve biodiversity. Many people would still like to see personal value instead of just value for the environment. One participant mentioned that:

"With reefs that are complete fences or balcony partitions that include spaces for birds and spaces for seeds you will score higher. And then especially focus on food and herbs on balcony and city garden" .

Most importantly, people do not like to put in a lot of time and work, it needs to be simple and not too time consuming. One participants even mentions:

"People are not used to nature, birds will shit on things, insects will come to the reef. This will be more work for people and people do not like to put in more work. "

So from this research we can conclude that it is very important, especially when designing for urban citizens, to make living artefacts that can be personalised, the added value to the user and the environment is clear and the (estimated) amount of time and effort for maintance/care is clear.

Limitations of survey

This survey only had 25 participants. Only a limited target group was reached, mainly through personal network and some professional network. Even though there was a relatively good variation of opinions, age and households, there is still room for improvement. For example more men could be reached as well as more households with a higher income, especially as Urban reef will likely have expensive reefs that will me more targeted towards higher incomes.

The concepts were very limited and needed some kind of imagination. Additionally many of the concepts were open to interpretation. Therefore participants of the survey had many questions or had trouble answering some questions at some points.

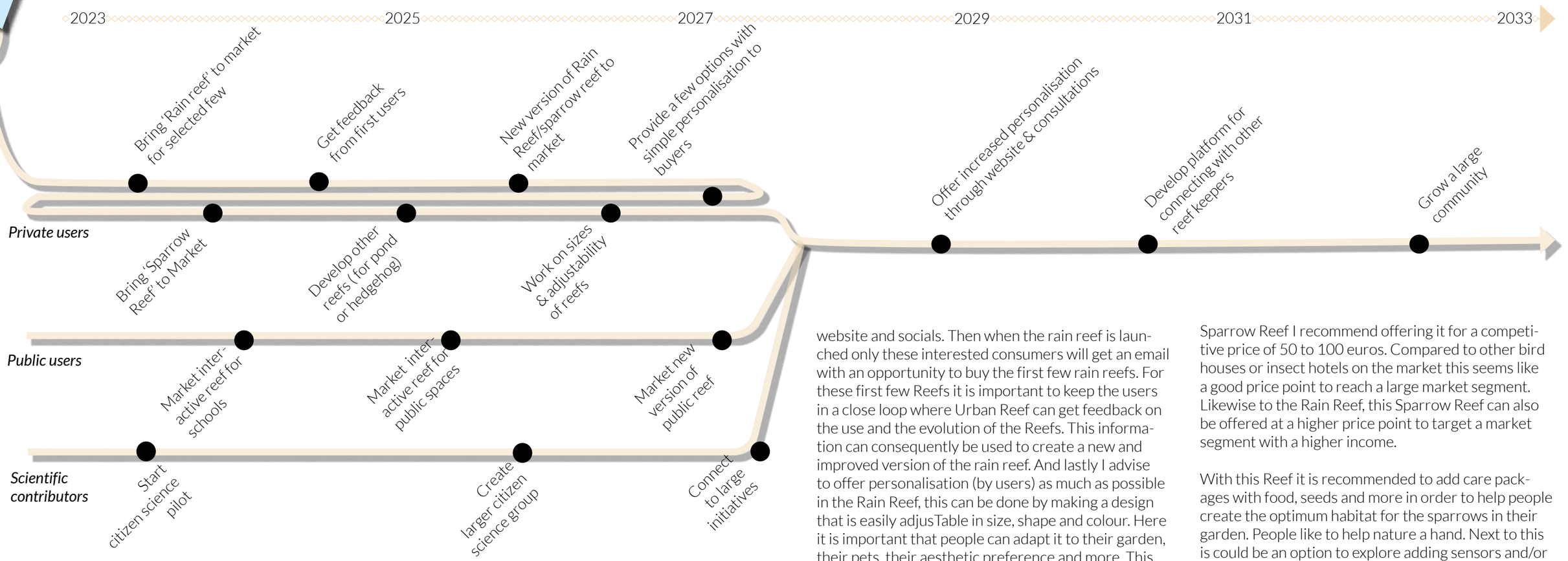
Further, the willingness to buy a reef (and additional packages) depends a lot on the price and that was not presented. More research needs to be done towards the pricing of the reefs.

Lastly it is advised to do more research with designs that are more detailed, keep contacting possible users for input sessions etc.

10. Recommendations Urban Reef

Based on the research done for this project a lot of information has been gathered on possible directions for Urban Reef to take in the future. In this Chapter a final advice will be given explaining which actions are recommended for Urban Reef to take in the future in order to bring successful products on the market that will make users feel more connected to nature.

This recommendation will be outlined through a roadmap of the coming 10 years. Within the explanation of the roadmap some references will be given of platforms to use and more. Lastly the Chapter will close of with some recommendations on future user research.



Roadmap

Based on the insights from the user research done and the knowledge of the progress & goals of Urban Reef I recommend three categories for future reef users: Private users, Public Users and Scientific Contributors. These three categories will together contribute to creating a large community of reef users throughout the Netherlands and beyond.

Private users - Rain Reef

Many of the 'private users' are interested in the Rain Reef as this has a clear function for the users to collect rainwater that they can also use for other plants in their garden. I advise to bring this Rain Reef to the market as soon as possible (end of 2023 or start of 2024). In order to reach a large market segment it is advised to offer a small rain reef (60-100 Litre) of the competitive price of 150 euros. There are many rain barrels to be found on the market for under this price point. However in order to reach a higher income segment it is possible to offer a larger Rain Reef (260-320 Litre) for a price of max 500 euros. There are a few rain barrels on the market which are made from natural materials and offer space for some plants. This shows that there is interest in these kinds of natural rain barrels which offer a space for plants/biodiversity in the garden. Moreover, to differentiate yourself on the market it is important to highlight that each reef is one of a kind and that it will evolve together with each garden.

The first commercial version(s) of the Rain Reef can be put on the market through a Kickstarter or Indiegogo campaign to gather funds before production. However before a Rain Reef is developed for a competitive price it is possible to first bring a more expensive prototype version of the Reef to market via an exclusive pre-order system, similar to what Living Light is doing (https://livinglight.info/pre-order/) . Interested consumers can show interest via a form on Urban Reefs website and socials. Then when the rain reef is launched only these interested consumers will get an email with an opportunity to buy the first few rain reefs. For these first few Reefs it is important to keep the users in a close loop where Urban Reef can get feedback on the use and the evolution of the Reefs. This information can consequently be used to create a new and improved version of the rain reef. And lastly I advise to offer personalisation (by users) as much as possible in the Rain Reef, this can be done by making a design that is easily adjusTable in size, shape and colour. Here it is important that people can adapt it to their garden, their pets, their aesthetic preference and more. This will make the Reef really feel like their own personal Reef which will improve the connection between the user and the Reef.

Private users - Sparrow reefs & more

Next to the development of the Rain Reef I believe it is important for Urban Reef to keep developing different Reefs as well. Reefs will work the best if they are aimed at one (or a few) specie(s), so that the optimum habitat for that species can be created. On the other hand consumers like to have multiple options to choose from to fit their own needs and values (as has been shown in the research). Therefore I recommend to further develop the Sparrow Reef and bring it to the market as soon as possible after the Rain Reef. For this Sparrow Reef I recommend offering it for a competitive price of 50 to 100 euros. Compared to other bird houses or insect hotels on the market this seems like a good price point to reach a large market segment. Likewise to the Rain Reef, this Sparrow Reef can also be offered at a higher price point to target a market segment with a higher income.

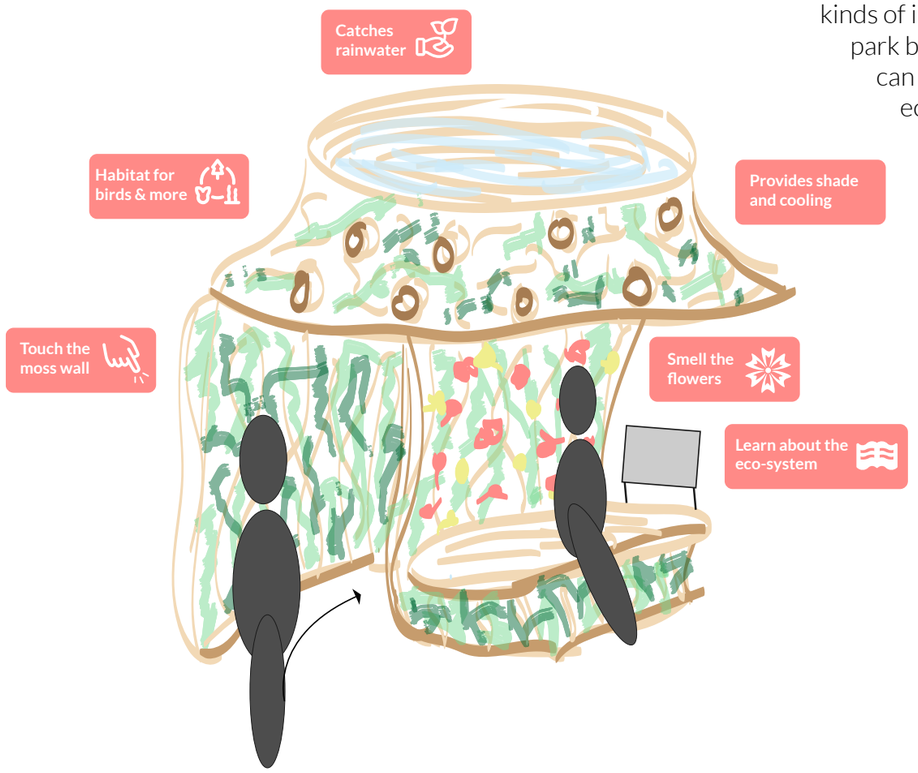
With this Reef it is recommended to add care packages with food, seeds and more in order to help people create the optimum habitat for the sparrows in their garden. People like to help nature a hand. Next to this is could be an option to explore adding sensors and/or a care taking dairy for people to keep a closer/mindful eye on their garden and the biodiversity in it. For this option I do recommend doing more research into the detail of this. Lastly it can be explored to make different versions with added personal functions such as: a large standing Sparrow Reef that can additionally offer shading for the users.

Next to a sparrow reef I recommend making more different kinds of reefs for private users, for example: A reef for in the pond, modular reefs for on the balcony railing, roof tile reefs, reefs for hedgehogs, reefs integrated into garden furniture. Here it is important to have reefs that either clearly create a habitat for one or two species or reefs that are integrated into the household/outdoor space of the users and provide a double function (one for human users and one for users of other species). When all of these Reefs (including the Rain Reef and Sparrow Reef) are marketed it is important to show the added value to biodiversity (in amount of species/ type of species/effect on eco-system) and the expected maintenance by users (time/ effort/money).

Public users

In order to have a larger impact on society, reach more urban citizens and make promotion for the Reefs of Urban Reef I recommend developing some interactive reefs for the public sector. These Reefs can be priced higher as the businesses in the public sector (schools, government etc) have a larger budget then individual consumers. Part of the income from these public Reefs can be put towards the production of the private Reefs.

Urban reef has already put some efforts into delivering Reefs to schools for educational purposes. I recommend to keep putting efforts into developing Reefs that can increase the biodiversity in the gardens of schools and additionally help children learn more about nature. In order to make sure that the children will actually feel connected with nature, it is important to make a reef that can be actively engaged with through different kinds of interaction with the senses. Can you let the children smell the nature on the reef, closely monitor it, describe or draw what they see? These interactions can be designed for multiple age groups, as children generally have a lot of interest into nature and to active engage with it (as was shown in my exploratory research).
However for the exact kind of interaction that is most beneficial for the development and nature connectedness of children more research has to be done. Next to using the Reef in education, I advise to make an Interactive Reef for in public parks (and other spaces). This Reef can help urban citizens to feel more connected to nature and it will be something different in the urban environment to interact with instead of just the normal green in the city. An example of a possible concept design of a park bench with shading is shown in Figure 34. This park bench has different parts which will prompt different kinds of interaction. Next to this park bench some information can be displayed about the ecological function of the bench.



Lastly this public Reef can be used to promote the commercially available Reefs for private use. well as the commercially available Reefs for private use.

Figure 35. Concept design interactive Reef

Scientific contributors

As has been shown by the citizen science research and by the user evaluation of the Concept Designs, there is some interest from citizens to help with research that Urban Reef is doing with current first versions of the Reefs. Around 20% of the participants were interested to buy a Reef with a citizen science package that would give them a discount on the price of the Reef. From all survey participants around 17 % of participant would be interested to buy the citizen science package without an additional discount on the Reef. It would become more attractive for an additional 46% of the group is a 20% discount would be offered. However for this group it can be argued if they have the right motivations for joining the citizen science project. Therefore, when offering a citizen science project where Reefs and equipment will be offered for a reduced (or free) price it is recommended to let participants sign an agreement and align motivations as well as expectations.

Due to the fact that Urban Reef is a young start-up which has Reefs that are still in development and limited resources to test all their hypothesise, I recommend setting up a citizen science pilot of at least 20 participants spread across the Netherlands. This will not only help with the functional development of the Reefs, but on the other hand also has the chance to develop a product that is more desirable to urban citizens. When citizens get the chance to contribute to a product and the environment, they will feel more connected to the outcome. To develop a successful citizen science project you can refer to: https://eu-citizen.science/, next to this website I have some personal insights on what steps to take in planning and guiding a citizen science project, these insight can be found in Appendix K. After the initial citizen science pilot I recommend setting-up a bigger citizen science initiative in order to start growing a larger community and gather more data. When you have a lot of data, you have a lot of useful information to join larger initiatives as well such as https://www.natuurmonumenten.nl/ . Platforms that can be used to gather and share data are: https://waarneming.nl/ or https://www.inaturalist.org/.

11. Conclusion Nature Connectedness through Living Artefacts

In this Chapter a short summary will be given of the thesis project. Next to this some recommendations for future research are given.

In conclusion, the objective of this project was to investigate the existing relationship between urban citizens and nature, and to propose adaptations for Urban Reef's Reefs to facilitate a sense of connectedness to nature among users. Through an initial phase of exploratory research and literature review, it became evident that there was a limited connection, as well as a lack of awareness and knowledge, concerning nature within urban environments. Subsequently, a second phase of research revealed that engagement with a living artefact (Reef) can significantly enhance human-nature connectedness. This was substantiated by a citizen science study involving a group of five participants who actively cared for and closely monitored a Reef. The findings demonstrated that participants underwent a transformation in their perception of nature and developed a meaningful bond with the Reef.

By combining the findings of the citizen science research with an extensive review of pertinent literature, a comprehensive collection of design guideline cards for living artefact designers was developed. This card set serves as a valuable resource, enabling designers to explore diverse approaches to adapt their ideas, designs, and prototypes, with the ultimate goal of creating living artefacts that foster an increased feeling of connectedness between (urban) citizens and the surrounding natural environment. The card set encompasses seven pathways to nature connectedness, derived from the original five pathways introduced by Lumber, Richardson et al. (2017), meticulously tailored to align with the living artefacts framework devised by Karana, Barati et al. (2020). These pathways include Living Aesthetics, Interactions, Affective Response, Habitabilities, Care & Compassion, Views of Nature, and Ecological Knowledge. Additionally, the cards feature a selection of concrete examples of Living Artefacts, providing tangible illustrations to support and inspire designers in their creative process.

Furthermore, three concept designs were developed by applying the design cards to the existing designs of Urban Reef's Reefs. These concept designs serve as illustrative instances of potential outcomes that can be achieved through the utilization of the design cards. Concluding the thesis project, a user evaluation was conducted to assess the design concepts, followed by recommendations for the future development of Urban Reef. These recommendations aim to guide the introduction of Reefs into the market within the forthcoming years.

The design cards presented in this research exhibit considerable potential for assisting designers in creating comprehensive designs that enhance users' nature connectedness. However, in order to ascertain their usability and impact on designers' ideas, designs, and prototypes, thorough testing is still required. To address this, I propose further development of these cards through rigorous testing involving a diverse range of living artefact designers. This can be accomplished by conducting individual user testing sessions, as well as organizing creative facilitation sessions involving multiple designers and potentially other stakeholders in the projects.

Additionally, I suggest conducting a more extensive research study with a larger sample group (n=minimum 50) of urban citizens. This study would focus on evaluating the proposed design changes derived from the design cards, specifically relating to Reefs or another type of living artefact, in comparison to a control group. To assess the feeling of nature connectedness, the Nature Connection Index (NCI) can be utilized, administered both before and after the research activities.

Moreover, I recommend incorporating qualitative studies alongside the quantitative research. These qualitative studies should involve Urban Reef and/or other living artefacts to delve deeper into the complex psychological construct of nature connectedness. The insights gained from these qualitative studies can be employed to enrich and enhance the design cards.

12. Personal Reflection

Throughout the course of this Thesis Project, I have gained invaluable insights and acquired numerous valuable lessons. It has been a transformative journey, marked by both many accomplishments and challenges. Most importantly, I have learned effective self-management strategies within the context of an individual project. On the other hand, I have honed my ability to navigate the dynamics and expectations of various stakeholders, ranging from supervisors to research participants. The process of conducting user research and setting-up a mini citizen science project has allowed me to refine my research skills and expand my knowledge base. Furthermore, this project has presented a unique opportunity to delve into the intersection of nature, living artefacts, and people—a totally new field of research for me. Along this journey, I have continuously absorbed knowledge and experienced personal growth. Overall, the lessons learned throughout this project are extensive and profound, making it challenging to summarize the breadth of my newfound understanding

Managing Myself

The Thesis Project Assignment offered a unique individual assignment of great scale and autonomy compared to my undergraduate studies. To overcome the challenges posed by my ADHD, I consciously created a supportive environment by establishing a lot of creative social contact (user research & brainstorming), establishing structure and routine, and seeking peer support.
Initially, I established a solid routine, and engaged in effective brainstorming and user research. However, I faced challenges when overwhelmed by numerous ideas without clear reference points. Realizing the project was slipping out of my control, I sought guidance from supervisors and peers, holding regular feedback sessions to maintain focus and project scope.

Resisting the temptation to deviate from the core objectives and avoiding overwork became challenging. Nevertheless, I persevered, consolidating efforts and maintaining focus. I learned to prioritize rest, set realistic expectations, and establish stricter deadlines for task prioritization. Balancing structure and flexibility became crucial. I now prioritize depth and richness of results over shallow work. Collaboration, user research, and productive brainstorming remain integral to my process.
This project has provided profound personal growth and valuable lessons that will shape my future design projects.

Managing stakeholders

This project marked my first experience working closely with three supervisors, which brought forth a wealth of input, opinions, and meetings. I thoroughly enjoyed our interactions and valued the opportunity to learn from each of them. However, navigating different perspectives and aligning project goals with the company and my supervisors required a delicate balance. Through trial and error, I discovered the significance of effectively presenting my project and personal goals to minimize miscommunication. Taking the time to align everyone's objectives and foster mutual understanding proved crucial, and I intend to prioritize this aspect in future projects.
In addition to collaborating with my supervisors, I also engaged with numerous research participants. This reinforced the importance of clear communication regarding the research and the living artefact, along with managing expectations. Every stakeholder brought their unique perspective and opinions to the project, even when their views differed from my own. While it may be challenging to hear opposing opinions, I believe there is much to learn from these exchanges. Each conversation broadened my understanding of the world and how individuals perceive it.

User research & citizen science

During the course of conducting user research activities, I discovered the vast amount of knowledge and insights that can be gained in this field. Every interview and creative session revealed new learnings. One key observation I made was the influence of my concentration and energy levels on the quality of interviews. I noticed that interviews conducted at the end of the day were less focused, with longer and overlapping questions. I realized the importance of keeping focus on the interview participants. Additionally, I recognized the need to delve deeper into their motivations by asking why and summarizing their stories to ensure a thorough understanding. While these were skills I was already aware of, it was valuable to be reminded of them and to continue practicing and honing these abilities.

Moreover, this project provided my first opportunity to actively incorporate citizen science beyond user research. I strived to involve prospective users extensively in the process and utilized various co-creative techniques. This approach generated a diverse range of rich insights. However, it required finding a balance between what I could prepare and plan beforehand and what I needed to leave open for user involvement. Considering that users may not possess all the necessary knowledge and available time, striking this balance was crucial. Although I aimed to keep the process concise yet open, I found that the time required swayed between just enough and too much. For future projects, it is important to continually seek this balance and explore more co-creative and citizen science approaches. Given the extensive nature of this topic, I remain highly interested and eager to continue learning and expanding my understanding.

Designing with nature & living artefacts

This project marked a significant milestone for me as it was my first endeavor working with a natural species and a living artefact. This topic has always captivated my interest, but I hadn't previously found the time or opportunity to explore it. I am immensely grateful for the chance to engage with this subject and contribute to the evolving field of design. Designing with and for nature, through living artefacts and other products/services, holds great importance, particularly in the face of pressing climate change and biodiversity decline. However, I also realized that my own knowledge of nature is still limited. Throughout this project, I thoroughly enjoyed expanding my understanding by engaging with experts in Biodesign and ecology. I consider this project as the starting point of my career, where I will continue to deepen my knowledge of nature, sustainability, and human psychology. My aim is to create products and services that foster people's connection with nature while making a positive and sustainable impact on our climate.

13. Closing word

This thesis project has been a long and challenging journey, perhaps longer than I initially anticipated (and my supervisors as well). However, I am genuinely pleased with the final outcome of this thesis and would like to express my gratitude to all those who contributed to its completion.

First and foremost, I would like to extend a heartfelt thank-you to my supervisors, Elvin Karana and Rebecca Price. Your unwavering support, knowledge, and guidance have been instrumental in reaching this point. Thank you for helping me realize my full potential as a designer and for your tireless efforts in keeping me focused.

I would also like to express my gratitude to my company supervisor, Pierre Oskam. Your time, ideas, reflections, and guidance have exceeded expectations, providing me with valuable insights to contemplate. Additionally, I would like to thank the other employees at Urban Reef: Max Latour, Dave, and Nilum, for their assistance in answering my inquiries and supporting my research endeavors. A special thank you to Max and Pierre for lending me (and the research participants) their reefs and funding my research activities.

I am grateful to all the experts who provided their valuable assistance during my project, especially Joren Wierenga, who aided in the Chlorella Vulgaris experiments. I would also like to acknowledge the contributions of Joanna Martins, Sandra de Vries, Marit Bogert, and other TU Delft employees.

Most importantly, I want to extend a very big thank you to all the research participants who generously dedicated their time and contributed to my research activities, particularly those who devoted a significant portion of their time during a two-week period as part of the citizen science research.

Lastly, I would like to express my deep appreciation to all my friends, peers, partners, and family who have supported me throughout this journey. Without your love and encouragement, none of this would have been possible.

14. References

Barragan-Jason et. Al, 2021

DiSalvo, C. and J. Lukens (2011). "Nonanthropocentrism and the nonhuman in design: Possibilities for designing new forms of engagement with and through technology." From Social Butterfly to Engaged Citizen: Urban Informatics, Social Media, Ubiquitous Computing, and Mobile Technology to Support Citizen Engagement: 421-436.

eu-citizen-science (, 2023). "what is citizen science?". from https://eu-citizen.science/.

Gemeente-Rotterdam (, 2023). "Begroting 2023: Sustainable development Goals (SDG, Duurzame ontwikkelingsdoelen)." Retrieved 23rd of February, 2023, from https://www.watdoetdegemeente.rotterdam.nl/apps/begroting2023/paragrafen/sustainable-goals/.

Godin, D., and Zahedi, M. (, 2014). "Aspects of Research through Design: A Literature Review." Design's Big Debates - DRS International Conference 2014.

Graham, D. (, 2017). City-dwellers increasingly disconnected with nature, reveals poll. . BBC Countryfile. Countryfile, BBC. **2017**.

Guillitte, O. (, 1995). "Bioreceptivity: a new concept for building ecology studies." Science of The Total Environment **167**(1): 215-220.

Hooykaas, M. J. D., et al. (, 2020). "Expanding the Role of Biodiversity in Laypeople's Lives: The View of Communicators." Sustainability **12**(7): 2768.

Karana, E., et al. (, 2020). "Living artefacts: Conceptualizing livingness as a material quality in everyday artefacts." International Journal of Design **14**(3): 37-53.

Kardel, K., et al. (, 2015). "Preliminary Development of 3D-Printed Custom Substrata for Benthic Algal Biofilms." 3D Printing and Additive Manufacturing **2**: 12-19.

Lazrus, H. (, 2015). "Risk Perception and Climate Adaptation in Tuvalu: A Combined Cultural Theory and Traditional Knowledge Approach." Human Organization **74**: 52-61.

Lumber, R., et al. (, 2017). "Beyond knowing nature: Contact, emotion, compassion, meaning, and beauty are pathways to nature connection." PLoS ONE **12**.

Manzo, L. C. (, 2003). "Beyond house and haven: toward a revisioning of emotional relationships with places." Journal of Environmental Psychology **23**(1): 47-61.

Mohajerani, A., et al. (, 2018). The Urban Heat Island Effect, its Causes, and Mitigation, with Reference to the Thermal Properties of Asphalt Concrete.

Preiser, R., et al. (, 2017). "Navigating alternative framings of human-environment interactions: Variations on the theme of 'Finding Nemo'." Anthropocene **20**: 83-87.

Radic, B. and S. Gavrilovic (, 2020). Natural Habitat Loss: Causes and Implications of Structural and Functional Changes**:** 1-14.

Richardson, M., et al. (, 2020). "Applying the pathways to nature connectedness at a societal scale: a leverage points perspective." Ecosystems and People **16**.

Urban-Design-Group, C. (, 2023). "What is Urban Design." 2023, from https://www.udg.org.uk/about/what-is-urban-design.

Urban-Reef, C. (, 2023). "Urban Reef." Retrieved 22nd of August, 2022, from https://www.urbanreef.nl/.

van den Broek, S., de Rooij, A., and van Dartel, M (, 2022). "Living with living artefacts: Six concepts for designing user acceptance of living artefacts." DRS2022: Bilbao.

15. Appendices

Table of contents Appendices

Appendix A - Project Brief

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name [redacted]
initials
student number
street & no.
zipcode & city
country
phone
email

SUPE
Fill in t

** chair
** mentor
2nd mentor

comments (optional)

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

TU Delft

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF
To be filled in by the chair of the supervisory team.

chair [redacted]

CHEC
To be fi
The stu

Master
Of wh
into acco

List of electives obtained before the third semester without approval of the BoE

name _____ date - - signature _____

FORMAL APPROVAL GRADUATION PROJECT
To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **. Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: APPROVED NOT APPROVED

Procedure: APPROVED NOT APPROVED

comments

name _____ date - - signature _____

Initials & Name D.S.M. Verkerk Student number 4449169

Title of Project Exploring the social domain of Urban Reefs (a bio-receptive artefact)

Exploring the social domain of Urban Reefs (a bio-receptive artefact) project title

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

start date 09 - 09 - 2022 17 - 03 - 2022 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Due to an increasing global population and urbanisation, cities around the world are exceedingly dense with many concrete structures. Many forest are being taken down and more houses are built every day. Space for natural habitats has disappeared from cities and biodiversity is at risk. The disappearance of urban green and biodiversity has resulted in the creation of the urban heat island effect and inadequate ecologically resilient cities. Furthermore, as a result of flora and fauna disappearing from the city it has been shown that the citizens have little to no connection to the nature (1). In our modern day society many of us do not feel as part of nature. Naturally, every location is different and has its own environmental and sociological factors at play which influence the local climate. And in turn changes in the biodiversity will also influence the social climate.

The company Urban Reef has designed a bio-receptive artefact that they call urban reefs. Reefs are defined as "porous, labyrinthic shelters/water-retentive structures that can host a spectrum of buffers and micro-climates thus providing grounds for a climate-adaptive and multi-species world.". These urban reefs are currently made of 3d printed bio-receptive ceramics and different organisms can grow on them. Additionally the idea is that in the future people can interact with the reef not only through senses but with the use of sensors and feedback in an app. Currently Urban Reef is located in Rotterdam and also in contact with the municipality of Rotterdam. They are mostly funded by subsidies from different funds. These urban reefs, increase the local biodiversity, purify the air and bring down local temperatures. Therefore many municipalities are interested in adding these bio-receptive artefacts to their cities ass they will help them reach their climate goals (2).

These urban reefs are a prime example of living artefacts as they will foster different living organisms and therefore take on different shapes and habitats for animals. As there is currently a lot of research into the ecological benefit of these bio-receptive artefacts there has been little research done into the social dimension of such living artefacts (3). These artefacts are placed in several locations where they will be perceived by local citizens and visitors. Now, the question poses what the current social dimension is of these urban reefs and how they can optimally increase the connection between people and nature as well as increase the local biodiversity?

Main stakeholders:
Urban Reef, TU Delft, IDE faculty, Me, My supervisors, Municipality of Rotterdam, Municipality of Delft, Government Netherlands, Other potential stakeholders (potential market) that has not been identified. The Planet, Flora and fauna.

(1) Graham, D. (2022, 25 januari). City-dwellers increasingly disconnected with nature, reveals poll. Countryfile.Com. Geraadpleegd op 22 augustus 2022, van https://www.countryfile.com/go-outdoors/city-dwellers-increasingly-disconnected-with-nature-reveals-poll/
(2) Urban Reef. (2022). urban reef. Geraadpleegd op 22 augustus 2022, van https://www.urbanreef.nl/
(3) Karana, E., Barati, B., & Giaccardi, E. (2020). Living artefacts: Conceptualizing livingness as a material quality in everyday artefacts. International Journal of Design, 14(3), 37-53.

space available for images / figures on next page

introduction (continued): space for images

image / figure 1: Theoretical example of uban reef in the city (1)

image / figure 2: Example of urban reef prototype with vegetation (1)

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

For the scope of this project I will focus my (field)research on three locations: The Bluecity, the Diergaarde Blijdorp Zoo (in the butterfly garden), and a third location in Delft (which has yet to be determined from research).

The main question: What is the current social dimension of urban reefs and how should the urban reef be adapted to be socially and ecologically embedded in the local environment?

The knowledge gaps that need to be addressed is categorized according to the three principles of living artefacts: (A) Living Aesthetics, (B) Mutualistic Care and (C) Habitabilities (3).

(A) Living Aesthetics:
- How do people perceive and experience the urban reef?
- Which techniques can facilitate the adaptation of the urban reef and other similar bio-receptive living artefacts into daily life?

(B) Mutualistic care:
- How do people currently interact with the urban reef and the environment?
- How should people interact with the urban reef and the environment?

(C) Habitabilities:
- First habitat: What conditions (within the urban reef) are needed for the biodiversity to develop and thrive on the urban reef? And should people play a part in influencing this? If yes, how?
- Second Habitat: What conditions are needed on the location (outside of the urban reef) for the biodiversity to develop and thrive on the urban reef? And should people play a part in influencing this? If yes, how?

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

To research the social dimension of urban reefs on three separate locations (Bluecity, Blijdorp, Delft) and define the desired relationship(s) between people, the urban reef(s) and the floara and fauna. To create a method/tool that demonstrates how to adapt the urban reef to be socially and ecologically embedded into different urban environments.

Design outcome:
- Report on social dimension of the urban reefs on three locations
- Defined desired relationship(s) between people, urban reef(s) and flora and fauna
- Different methods and (small) prototypes that adapt the urban reef to be more socially and ecologically embedded in different environments.
- Tests that demonstrate the effect of these methods/prototypes on the biodiversity and the experience of people.
- One overall tool/method that demonstrates how to adapt the urban reef to be socially and ecologically embedded into different environments.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and 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 activities.

start date 9 - 9 - 2022 17 - 3 - 2022 end date

My graduation project will consits out of 5 phases: 1) Context Research, 2) Design direction, 3) Ideation & concept design, 4)Prototype development & evaluation and 5) Documentation. See last page for Gantt Chart (4 workingdays pe r week, so I can work more efficient especially with ADHD &IBS).
1) I will reach out to needed parties for the context research. Both municipalities and other local stakeholders in both neighborhoods.
1) Literature research into biodiversity, social factors and case studies on both these topics. 1)Interview experts from urban reef, municipalities and other companies. And define the third location for an urban reef
1) Research the local biodiversity in the field, observations and interviews on the street and more.
2) The design brief will be redefined after gathering insights from context research
2) First design directions will be identified from research which will be used as prompts in co-creation sessions
2) Co-creation sessions with local citizens and other representatives to define the relationship between people, nature and the urban reef.
2) After co-creation session the design direction will be set.
3) First ideation, some first ideas for adaptation will be presented at the midterm
3) Another co-creation session with stakeholders to develop ideas and concepts together, and choose the best.
4) Testing out different methods/prototypes to socially embed the prototype.
4) Start working on an overall method/tool that documents my process.
4) Adapting prototype/tool to be adjustable to different neighborhoods, test tool on other neighborhood.
5) Documentating design and the process, and making a video that explains the social dimension of urban reefs.

Personal Project Brief - IDE Master Graduation

TU Delft

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

It has always been my passion to work in the sustainability and social design field. Next to that I have had a growing interest to design with and for nature. That is why I reached out to urban reef and to Elvin Karana because it fits within my expertise and interest. On the field of designing with nature/living things I still have a lot to learn, but I am excited to dive deeper into the literature and field research within this graduation. I will also follow some lectures from the master electives from Elvin: Designing with living artefacts. This will support me in my own graduation.

During my internship at the municipality I already have learned a lot about social design and doing research in the public realm. However I missed a connection with sustainability and nature there which I have found in this project. As part of this internship I did a lot of interviews and many co-creation sessions. I want to develop myself even more on the subject of this creative interviewing techniques such as co-creation, to get to the core of what people really want and need. Additionally, I also want to supplement this with observation techniques and much more to integrate the natural perspective with the human perspective.

Additionally, I want to work more on my managing of stakeholders and communication skills, this is also part of the reason I chose to work with an external company. During my bachelor and masters I have already practiced with managing stakeholders however not on this level with a large personal project yet. I mostly want to work on making clear agreements and to the point communication, with all my supervisors. I want to make my communication more visual and to the point. In the past it sometimes was a bit too complex and chaotic and I want to work on being more structured and effective.

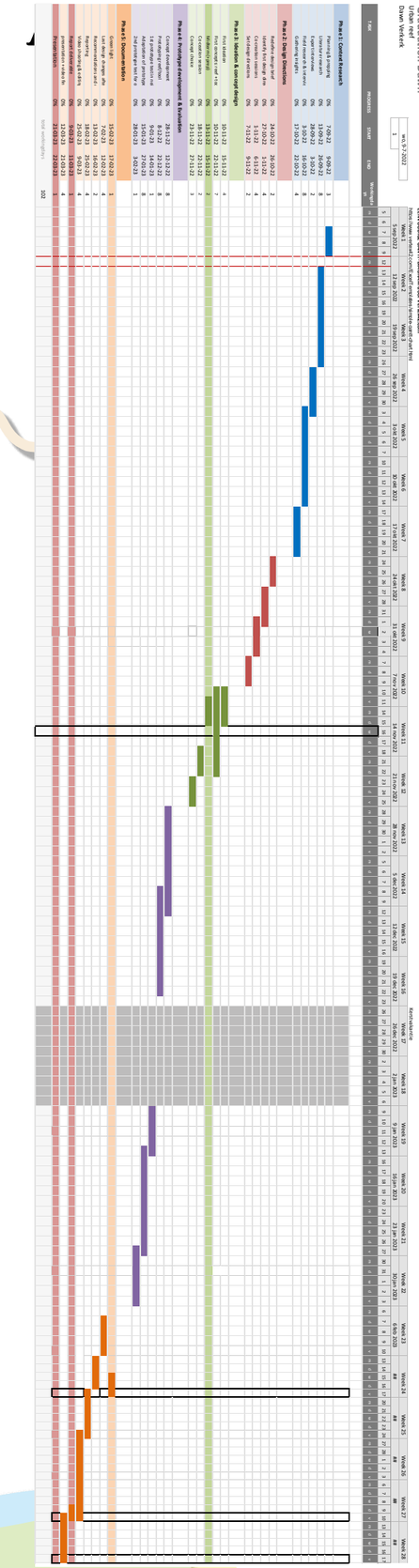
Lastly I want to gain more experience with new methods, making my own methods and also with prototyping different kind of products/systems/tools. Therefore I plan to do a lot of field work on location, and make physical prototypes that can actually be tested with participants so that I can show the effect of design changes. Also to not make another theoretical design solution but create something that actually works and is tested.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Initials & Name D.S.M. Verkerk Student number 4449169

Title of Project Exploring the social domain of Urban Reefs (a bio-receptive artefact)



Appendix B: Recruitment questions citizen science research

Onderzoek Urban Reef en Algen

Wat leuk dat je geïnteresseerd bent in ons helpen met dit onderzoek. In dit formulier kan je aangeven dat je interesse hebt om mee te doen met het onderzoek. Wij zullen eerst een aantal vragen stellen en op basis van deze vragen zullen we kijken of je geschikt bent om mee te doen met het onderzoek, vul alstublieft de vragen zo eerlijk mogelijk in.
De geselecteerde deelnemers zullen voor 12 maart een e-mail bericht ontvangen met bevestiging van deelname.

Meer informatie over het onderzoek:

Urban Reef (https://www.urbanreef.nl/) ontwerpt en maakt ge-3D-printe keramische ‘Reefs’, die begroeid en bewoond
worden door verschillende plant- en diersoorten. Hiervoor doet de start-up onderzoek naar de rol van algen als voedingsbodem.

Deelnemers aan het onderzoek ontvangen een ge-3D-printe keramisch prototype met algen erop. Je zorgt gedurende twee weken voor het sculptuur met algen binnenshuis en documenteert het proces met bijgeleverde klimaatsensoren en foto’s.

Na afloop kun je het prototype in je eigen tuin of op je balkon plaatsen en de natuur haar gang laten gaan. Naast het verzorgen van het prototype (5 à 10 minuten per dag), vragen we deelnemers om deel te nemen aan een groepssessie op 15 en 29 maart en een persoonlijk interview (30-60 minuten) in de week van 20-24 maart.

Alvast heel erg bedankt namens Dawn Verkerk en het team van Urban Reef
*Door dit formulier in te vullen geef je toestemming aan de onderzoekers van Urban Reef en de TU Delft om de ingevulde data te gebruiken voor dit onderzoek. De gegevens die je hier invult zullen geanonimiseerd worden voor onderzoeksdoeleinden en niet openbaar gedeeld worden. Na een periode van 5 jaar wordt de data van dit formulier verwijderd.

* Verplichte vraag

1. E-mailadres *

2. Wat is je naam *

3. Wat is je gender? *

Markeer slechts één ovaal.

- ◯ Man
- ◯ Vrouw
- ◯ Non-binair
- ◯ Anders: _____

4. Wat is je leeftijd? *

_____

5. Wat is je hoogst genoten opleiding? *

Markeer slechts één ovaal.

- ◯ Geen opleiding (basisschool niet afgemaakt)
- ◯ Basisschool
- ◯ Middelbare school
- ◯ MBO
- ◯ HBO
- ◯ WO Bachelor
- ◯ WO Master
- ◯ PHD
- ◯ Anders: _____

6. Wat is je huidige beroep/occupatie? *

_____

7. In wat voor gebied ben je opgegroeid? *

Markeer slechts één ovaal.

- In de stad
- Op het platteland
- Aan de rand van de stad en platteland
- Anders: _____

8. Wat is je huidige woonsituatie? *

Markeer slechts één ovaal.

- Alleenwonend
- Ik woon met huisgenoten
- Ik woon met mijn partner(s)
- Ik woon met mijn partner(s) en kinderen
- Ik woon met mijn kinderen
- Anders: _____

9. Heb je een tuin of een balkon? *

Markeer slechts één ovaal.

- Ja, ik heb een eigen tuin
- Ja,ik heb een eigen balkon
- Ja, ik heb een gedeelde tuin
- Ja, ik heb een gedeeld balkon
- Nee

10. Hoeveel kennis heb je van verschillende planten- en diersoorten? *

Markeer slechts één ovaal.

Heel weinig kennis

1
2
3
4
5

Heel veel kennis

11. In hoeverre ben je het eens met de volgende stellingen? *

Markeer slechts één ovaal per rij.

	Helemaal niet mee eens	Niet echt mee eens	Niet mee eens of mee oneens	Een beetje mee eens	Heel erg mee eens
Mijn ideale vakantie spot zou een afgelegen wild gebied zijn.					
Ik denk altijd eraan wat het gevolg is van mijn acties op het milieu.					
Mijn connectie met de natuur en het milieu is deel van mijn spiritualiteit					
Ik ben me bewust van wild leven waar ik ook ben.					
Mijn relatie met de natuur is een belangrijk deel van wie ik ben.					
Ik voel me erg verbonden met alle levende wezens en de aarde.					

12. Ik ben beschikbaar op 15 maart op de volgende tijden: *

Vink alle toepasselijke opties aan.

- [ ] 12:00 - 13:00
- [ ] 13:00 - 14:00
- [ ] 14:00 - 15:00
- [ ] 15:00 - 16:00
- [ ] 16:00 - 17:00
- [ ] 17:00 - 18:00
- [ ] Anders: _____

13. Ik ben beschikbaar op 29 maart op de volgende tijden: *

Vink alle toepasselijke opties aan.

- [ ] 12:00 - 13:00
- [ ] 13:00 - 14:00
- [ ] 14:00 - 15:00
- [ ] 15:00 - 16:00
- [ ] 16:00 - 17:00
- [ ] 17:00 - 18:00
- [ ] Anders: _____

14. Heb je nog andere opmerkingen of vragen?

_____

_____

_____

_____

_____

Appendix C - Interview questions citizen science research

Goal research

Finding out what people's experience is, do they feel more connected to nature/the reef? And why, how, what things specifically? How do they find citizen science, how can it be improved?

Explanation before start

I would like to find out what your experience is, there are no right or wrong answers. Please think out loud and share as much as you can with me.

Instructions before start

- Take pictures!
- Turn on recorder
- Check if the person has given permission for this

Name:
Prototype number:

1. How did you feel about doing the experiment last week and having the reef in the house?
- Why is this so? What caused this?
- Did you find anything difficult or just really easy and nice?

2. Are there any improvements for the experiment that you would give? If you could do it again from the beginning what would you change(as a researcher)?
- Or things you thought were just right?
- And why?

3. How do you think the reef is doing now?
- Why is it like this? What causes this?

4. How did you pay attention to the reef last week?
- Why this kind of attention?
- How did you feel about taking care of the reef? How did this make you feel?

5. How do you feel about the reef now compared to at the start?
- What is different? Why?
- Do you have a bond with it?

6. What do you think of the reef's appearance (shape/ colour etc)?
- Does it remind you of anything? Of what and why?
- How would you describe it (beautiful/ugly/robust)?

7. Would you want a different form of interaction with the reef? (Otherwise wanting to care for, or just get something out of it in return)
- What for and why?

8. To what extent do you consider the reef (with algae) a natural object? (0 - totally not natural/ cultural/ man-made and 10- very natural/ wild-life)
- Why is this so?

9. How connected do you feel to nature and all living things around you? (From very connected - 10 and totally unconnected - 0)
- Why is this so?

10. How did this experiment make you think about nature? And made you feel about nature?
- Did it make you think differently about nature/biodiversity? How exactly?

11. When you look at the city's eco-system, what do you see as the role of yourself and the reef?

12. Rain reef?

13. Other question?

Appendix D - Pilot research chlorella vulgaris Algae on Reef plan

Goal: Simulate algea growth (of chlorella vulgaris) on the ceramic surface, test the influence of the medium on algae growth.

Method: 3 different chlorella vulgaris mediums on 3 ceramic samples. Kept moist and supplied of regular oxygen, regulated light.

Research questions:
What is the optimal medium for chlorella vulgaris growth on ceramic surfaces?
How fast do the algae on each medium grow and develop? Under which circumstances does this happen? (Are there any other developments of other organisms?)

Setup:
3 similar (or different?) ceramic samples with 3 different medium of chlorella vulgaris algae: 1) Agar and fertelizer medium, 2) Agar, fertelizer + hydrogel, 3) Water with fertelizer. Each medium will be applied in a different manne(see procedure for more info). All of the samples will be supplied with regular water and nutrients through a layer of water with nutrients that will be spread with a humidifier/mist device.

Apparatus:
Plastic container (39 x 58 x 43 cm)
Red/Blue LED light (+ light filter?) of boulampen
Air pomp (needs to be bought at Praxis)
Algae nutrients
25 g sodium alginate
10 g calcium chloride
Tapwater
15 g Agar
Autoclave or mixer
Brush/(wooden) spoons
Spray bottle
2x 300 ml of chlorella algae in freshwater
Water for inside all the samples to keep moist

Media:
Agar & fertelizer (1L)
15 g agar agar
0,33ml of fertelizer

790 ml of water
200 ml chlorella vulgaris (in freshwater)
total split in half
Fertelizer & hydrogel (1 L)
500 ml of medium 1
2 g of sodium alginate per 100 ml is needed (so if total 1 L then 20 g)
2.5 g calcium chloride + 50 ml of water
Water & fertelizer
100 ml chlorella vulgaris
299 ml water
1 ml fertelizer

Procedure:
Medium 1)
Prepare medium 1) by mixing 10 ml of fertelizer with 590 ml of water and 15 g of agar agar
Carefully stir the 200 ml of the chlorella algae with the medium

Let the medium sit for a few days (5-7?): under LED lights, regular temperature and aeration with the air pump to start growing proccess. (If it becomes greener
Split the medium up in to two parts evenly (2x 500 ml). Half will be used as medium 1, and half will be used for medium 2) by supplementing it with sodium alginate hydrogel.
Apply medium 1 on to the ceramic sample with a spoon/brush

Medium 2)
Prepare medium 1) by mixing 10 ml of fertelizer with 590 ml of water and 15 g of agar agar
Carefully stir the 200 ml of the chlorella algae with the medium
Let the medium sit for a few days (5-7?): under LED

lights, regular temperature and aeration with the air pump to start growing proccess.
Mix 2,5 g of sodium alginate with 250 ml of water.
Mix the sodium alginate with the medium with chlorella
Apply the alginate and algae mixture to the ceramic sample with a spoon/brush
Mix 2,5 g calcium chloride with 250 ml water and insert into a spray bottle

Spray Calcium chloride solution onto ceramic sample

Medium 3
Carefully stir 200 ml of the chlorella algae with 5 ml of fertelizer and another 300 ml of water
Let it sit for a few days (5-7?):under LED lights, regular temperature and aeration with the air pump to start growing proccess.
Immerse the ceramic sample in the water solution
Reguraly spray (every 4-5 days?) more nutrients onto the sample (10 ml fertelizer + 990 ml water)
Immerse the sample again in the algae and water solution after one week

Setting up/measuring:

Part 1: Culturing the algae. Let the agar medium with algae and the water with algae rest for a few days (5-7?) in a container with airpump, under LED light and

regular temperature.
Part 2: After finishing the all media and applying it to the samples. Place all three samples in the plastic container with a layer of water in it. Add a humidifier to keep it moist.
Add LED light on top of the plastic container
Add air pump to the container
Measure temperature and ph of water every 2 or 3 days
Make a picture of top view, left and right view every 2 or 3 days.
Make pictures and comments of any important details

Test both at Urban Reef and at home set-up (and compare)

Timeframe of experiments: minimum 15 days - maximum 30 days

Planning:
Thursday 23-02: Experiment with application of agar and hydrogel mediums. Prepping of water culture.
Monday 27-02: Setting up reefs at Urban reef and setting up pilot reefs at home.

28-02 to 13-03: Pilot period
13-03: make decision on how to continue
13-03 to 27-03; citizen science experiment
After 27-03: Place all reefs back at RDM

Measure:
Temperature environment
Airhumidity
Amount of light (lux)
Maybe ph of water?
Growth rate of algea is measured by pictures

Documentation:

3N-BBM+V (Bold Basal Medium with 3-fold Nitrogen and Vitamins; modified)

Stocks	**per litre**
(1) $NaNO_3$	75 g
(2) $CaCl_2.2H_2O$	2.5 g
(3) $MgSO_4.7H_2O$	7.5 g
(4) $K_2HPO_4.3H_2O$	7.5 g
(5) KH_2PO_4	17.5 g
(6) NaCl	2.5 g
(7) Trace Elements (PIV):	
Ensure elements are added in the following sequence:	
Na_2EDTA	0.75 g
$FeCl_3.6H_2O$	0.097 g
$MnCl_2.4H_2O$	0.041 g
$ZnCl_2$	0.005 g
$CoCl_2.6H_2O$	0.002 g
$Na_2MoO_4.2H_2O$	0.004 g
Once elements are dissolved autoclave at 15 psi for 15 minutes.	
	Per 100 ml
(8) Vitamin B_1 (Thiamine hydrochloride)	0.12 g
Filter sterile	
(9) Vitamin B_{12} (Cyanocobalamin)	0.1 g
Take 1 ml of this solution and add 99 ml Deionised water. Filter sterile.	

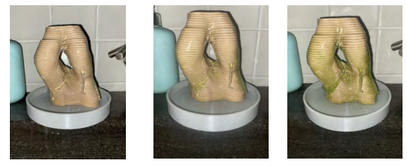
Medium	**per litre**
Stock solution 1 - 6	10 ml each
Stock solution 7 (Trace element)	6 ml
Stock solutions 8 - 9	1 ml each

Make up to 1 litre with distilled water. For agar add 15 g per litre Bacterialogical Agar. Autoclave at 15 psi for 15 minutes.

Reviewed: 22nd December 2021

Appendix E - Results citizen science experiment

1. RESULTATEN VAN HET EXPERIMENT

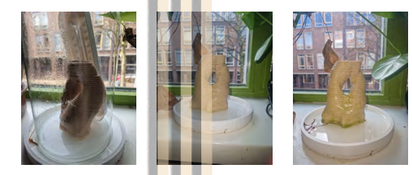


Prototype 1 Dag 1 Dag 5 Dag 10

Prototype 2 Dag 1 Dag 5 Dag 10

Prototype 3 Dag 1 Dag 5 Dag 10

Prototype 4 Dag 1 Dag 5 Dag 10



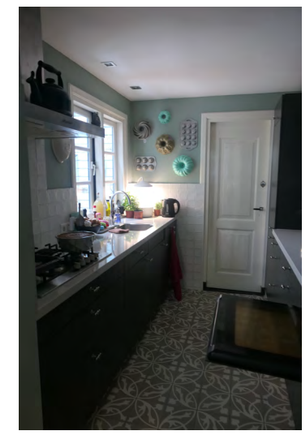
Prototype 5 Dag 1 Dag 5 Dag 10

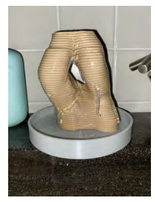
Pilot Urban Reef Dag 1 Dag 5 Dag 10

* *minder voedings-stoffen en algen*

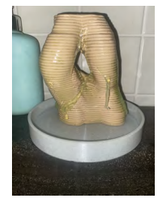
2. VERSCHILLENDE OMGEVINGEN

	Gemiddelde temperatuur (graden celsius)	Gemiddelde luchtvochtig-heid (%RH)	Gemiddelde lichtintensiteit (lux)	Foto omgeving	Opmerking omgeving
Prototype 1	22,4	74,9	4837,6		Onder groeilamp bij keukenraam (oost zijde?)

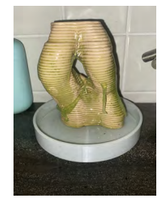




Prototype 1 Dag 1

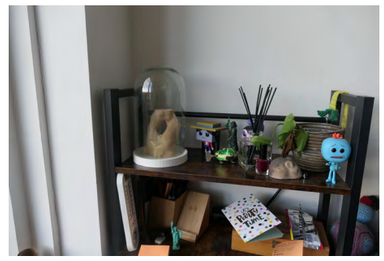


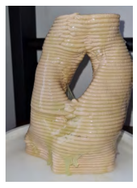
Dag 5



Dag 10

2. VERSCHILLENDE OMGEVINGEN

	Gemiddelde temperatuur (graden celsius)	Gemiddelde luchtvochtig-heid (%RH)	Gemiddelde lichtintensiteit (lux)	Foto omgeving	Opmerking omgeving
Prototype 3	19,2	55,6	1068,0		Vlakbij raam bij noord-oost zijde

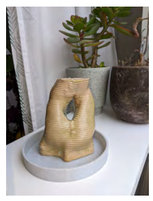


Prototype 3 Dag 1 Dag 5 Dag 10

URBA

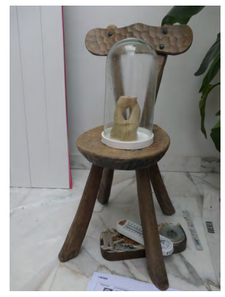
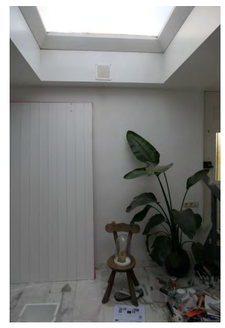
2. VERSCHILLENDE OMGEVINGEN

	Gemiddelde temperatuur (graden celsius)	Gemiddelde luchtvochtig-heid (%RH)	Gemiddelde lichtintensiteit (lux)	Foto omgeving	Opmerking omgeving
Prototype 2	21,6	63,0	7499,9		Bij het raam aan de zuid zijde



Prototype 2 Dag 1 Dag 5 Dag 10

2. VERSCHILLENDE OMGEVINGEN

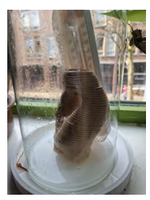
	Gemiddelde temperatuur (graden celsius)	Gemiddelde luchtvochtig-heid (%RH)	Gemiddelde lichtintensiteit (lux)	Foto omgeving	Opmerking omgeving
Prototype 4	18,5	66,7	4106,9	 	Bij het dakraam, licht van boven af.

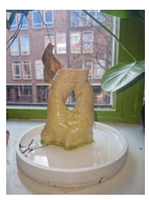


Prototype 4 Dag 1 Dag 5 Dag 10

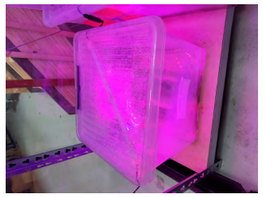
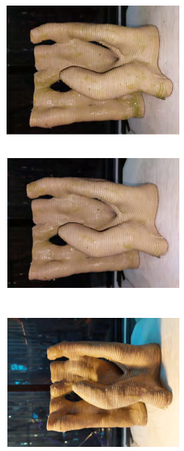
2. VERSCHILLENDE OMGEVINGEN

	Gemiddelde temperatuur (graden celsius)	Gemiddelde luchtvochtig-heid (%RH)	Gemiddelde lichtintensiteit (lux)	Foto omgeving	Opmerking omgeving
Prototype 5	22,2	73,0	1705,0		Bij het raam op zuid west.

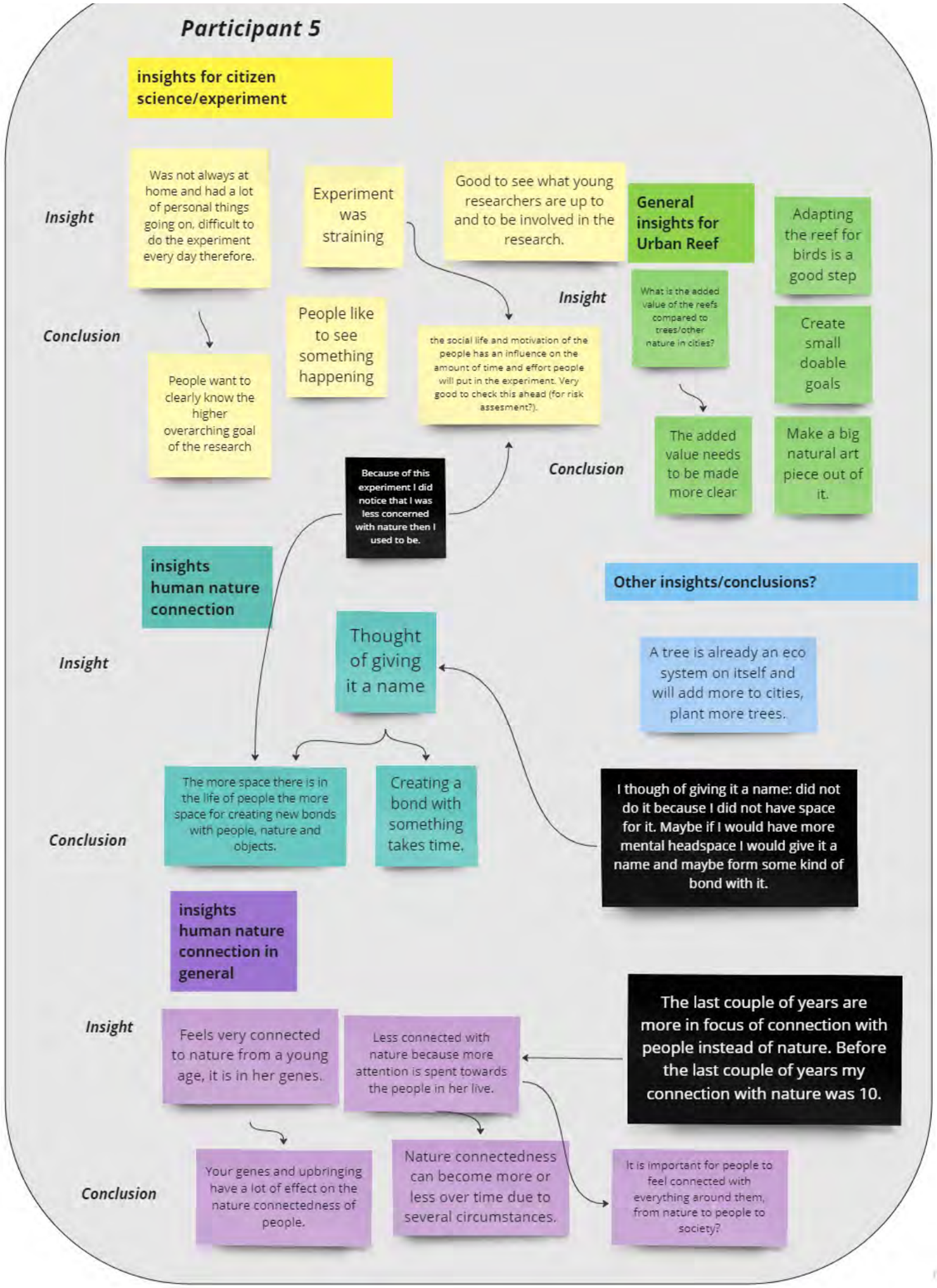




Prototype 5 Dag 1 Dag 5 Dag 10

	Gemiddelde temperatuur (graden celsius)	Gemiddelde luchtvochtigheid (%RH)	Gemiddelde lichtintensiteit (lux)	Opmerking omgeving	Foto omgeving
Pilot Urban Reef	19,0	78,0	5000,0	Onder groeilampen in in plastic box in green house.	 
Pilot Urban Reef * minder voedingsstoffen en algen					
Dag 1					
Dag 5					
Dag 10					

Appendix F - Analyzing interview outcomes



Participant 4

insights for citizen science/experiment

Good quote

Insight

logging in was a hastle with iPhone

Did not know what to expect. no reference as to wether she was doing good ot not. I did expect to see more.

Treated it like a fun pet project that made it more fun

two weeks every day is quite some effort, two weeks is enough.

Incorperated it in morning ritual, did get up 30 minutes earlier for it.

Filling it in on paper would be better, then you can just sit calmly. (Digital is ok, but logging in was a hastle)

. I found it nice to treat it like a fun pet project to also keep it fun instead of keep it this technical thing.

Conclusion

Doing the experiment needs to as easy as possible, check for iphone and android.

People need reassurance that they are doing well. Reference point as to what to aim for..

People like to see things happening, are unpatient.. Inform people that it nature needs time and not a lot might happen.

It can help to add aspects to make it fun and not only technical/scientific. (But might also feel less scientific therefore?)

Time frame and effort needs to match people's schedule and expectations.

Paper version would be more mindful

Hasle of digital things take away the mindfulness

I became a little more conscious that puddles of water are of course also very important for a lot of micro organisms/ insects etc, did not think about that before.

insights human nature connection Reef

Roommate Maria did experiment the last few days.

Experiment made me become more conscious of micro organisms in puddles of water

Insight

Yuri (reef) is getting used to home situation after around a week.

Yuri would rather have less mess and be outside.

Yuri likse a routine, needs regular attention.

It became a conversation piece talked with roommates about a regularly.

Touched and smelled once.

It felt like having a pet.

Yuri would have rather not have all the mess from the construction around him, he would rather want to be outside.

Because I gave it a name it made me feel jolly, was like a inside joke with myself, the reef and roommates. But it made it more personal also .

Conclusion

When people give the living object a name they start to think more about what the object likes/wants/needs.

Due to the seeing of changes you realise it is not a dead object but that it is alive.

More connection is created through talking about it with important people in their life.

People explore only shortly with their other senses, but don't do that again if not interesting.

It is an object but it is also something alive, you are aware that there is kind of like an organism there.

insights human nature connection in general

Insight

Started to feel more connected with nature over the years, slowly on from one point on.

Mostly notice nature through trees

A lot of feeling amasement by the force, change and beautful colors of nature.

We forget that we as people are also part of nature, it is all around us. And we are dependent of nature.

Maria was grown up on the country side. And her parents were also very aware of nature and always looking around and observing, this has influence as well.

difference between Iraas - grew up in city and Maria - grew up in countryside. Maria was always connected with nature, Iraas developed it later.

Before (when I was younger) I was less aware of nature. 7/8 years ago I starte d living more consciously. Thinking about how we live and what kind of influence we have and that we are dependent on nature

I always look outside to the birds, a lot of things get my attention. I kind of always had that

Conclusion

there is one moment of inspiration/ awareness and since then a building of the habit of noticing nature.

General insights for Urban Reef

Insight

Would be nice if it is more organic.

Color could be a bit more white even.

It needs to not look more organic/natural in order to go away from looking like art/ functional object.

We want to make a waddi in the garden for hwhen it rains a lot, could be nice to put the reef in the waddi.

Need to see the addedvalue for local nature and then we would spend more money on it.

The older I get the more combative I get, I want to do something actively for nature.

Conclusion

It is important that the shape reflects the livingness - so more organic/ natural shapes.

In order to look more alive it needs to look less like art or something functional.

Shape has someting droll, clumsy, funny.

To spend more money on it there needsto be a proven/ visual added value for people and/or nature

It can decrease the heat island effect, needs to be shown then.

Participant 3

insights for citizen science/experiment

Insight

Boyfriend helped with measerements on a day that I could not.

Hassle of water made the measurements take long - 30 mins

Did measurements while watching tv show/chatting.

Wondering exactly where the algae are gwrowing, in the gel or also under it.

Conclusion

It is easier to do when you have roommates that can help with the experiment if needed.

People have a hard time focussing on just one thing and always want to be multitasking/spending time productive/efficient.

insights human nature connection reef

Smelled the gel once or twice.

Talked about it with boyfriend (who lives with him), found it funny.

Is more interesting then other houseplant because you see a change a bit quicker. Also more personal.

You pay more attention to changes then with plants. also because of making the picture.

Curious about where the algae are growing - what is happening inside the living object

Glass bulb creates a feeling isolation

Insight

Becames a conversation piece, discussing the new thing and it's livingness

Sharing a task creates more connection with other person over doing a shared task.

Reef becomes part of the household. Kind of in between a houseplant and a pet.

Havng to pay attention to changes makes it more mindfull. more connection with it then with other nature.

Reef evokes a lot of curiousity and wonder.

Reef fits wel within the idea of making a small contribution to nature - providing a habitat for plants and animals.

Conclusion

It is nice to spend time with something every day, feels almost like a pet. In between a pet and a plant. If you do not have to pay attention to it everyday then it will become at the same level of my plants/ slug.

I study next to the reef, I like it. It is a bit more dynamic then most of my plants because you see a difference quicker then most of my plants. Curious to see how it will go with mosses.

insights human nature connection in general

Insight

Likes living in the city, does not want more connection with nature.

Nature should come to me in the city, I will not go out of my way to look for it.

social life / partying is an important part of life, I would not want to give that up to be closer to nature.

I worry about climate and biodiversity, think about nature a lot.

Puts flowers for bees on balcony.

I want more nature in the city everywhere.

Conclusion

Should be a balance between nature in the city but still having night life and other modern things in the city.

. But I believe nature should come to the city. I will not go out of my way to look it up. Living in nature does not have to take away of other happiness

Tries to do whatever small in power for biodiversity/nature.

General insights for Urban Reef

Insight

the beige color makes it feel more natural then a really white white.

Round shapes makes it organic.

Shape is interesting.

the dragon eggs from the website look a bit more sci-fy ish. This one is more natural but still spacey.

It would be cool if it live a living plant pot, I would pay money for that.

For a mid sized planter pot- reef - I would pay from 30-50 euros

A public version wouldbe nice, with information abou the research and local eco-system. I would want to contribute by giving it water.

Conclusion

Color has a lot of influence on how natural an object feels

Other insights/conclusions?

Rain reef - will that not start to stink soon.

For a rain reef I would pay 50-70 euros.

People would like to have nature for partly also some personal gain something they can influence and control.

A public reef shoud be mainly about awareness and education

If there is a reef in public very nice to see that attention is being put towards biodiversity and these things. Bringing people in contact with science and innovation through urban reef.

Participant 2

insights for citizen science/experiment

Good quote

Insight

Shared picture of reef progress with my husband and talkes about it with sister.

Made it easier by adding shortcut to the form on my phone homescreen.

Put reminder in agenda.

Became of morning routine, always around breakfast.

Some hassle with thermometer and leaking water.

Conclusion

People really like seeing progress and sharing their progress with loved ones

hard to think of extra attention ot give it.

Was easy to do because of reminder, shortcut on phone, integrating into routine.

Put reminder in agenda. Irritatted if I did not do it and still have the reminder popping up on phone.

Good to have a small thermomter integrated into it.

insights human nature connection Reef

Good to have questions that make people think for themselves what they can do more as part of the experiment and be creative. Does not work for everyone though.

Now I see that my tiles are green I am thinking should I take the green deposit of or leave it on. Maybe there are micro-organisms there and maybe it is nice instead of bad. First I had a negative outlook on the dirty green deposit, now I still think it is dirty but I think more this is part of nature and this is normal. Instead of dirty moss dirty is part of nature.

Insight

It is like taking care of the baby or of the sourdough bread (mix).

Because of the extra attention you start to think more of having another bond with the reef. (Like a pet bond then just an object or plant?)

I would like to have it on a more prominent place in the house, so you notice it ore.

More connection with the reef then with other plants

More aware that green deposit on building/tiles is nature and not necessarily bad.

Conclusion

Letting people clay/ create their own shape then you create more of a connection. Choose an animal that you want a habitat for, or as a kind of roof for an existing bird house.

Is seen as a (living) art piece that is nice to look at.

Most likely there is more connection because of the task of checking on it daily. Also because of the other shape?

Is aware of the role of the ugly hedge in garden for the local birds.

insights human nature connection in general

Insight

Likes to be in nature, looks at plants and animals.

Longing to do more for nature/sustainability.

Wants to use less energy, use car less etc and do better for environment

Not so much time and energy for it (it can cost a lot of time and energy).

Husband Robert is more cncerned with nature, through job and bird spotting etc.

Helping the birds is more important then what is nice to look at.

Conclusion

Sees living more sustainably as good for nature

Not that concerned with biodiversity, Are putting a sedum rof on the shed, should maybe wip out more tiles in the garden and let less plants die.

General insights for Urban Reef

Insight

Neutral color is good - not too eyecatching.

Less straight lines and less smoothness/more texture would let it look more natural.

Shape looks like legs - like art. Art is a good thing, but less natural and more man made.

Outside I hope it starts fending for itself, only checking on it once in a while.

I would want to have the reef as some form of planter, or border between garden and tiles, or birdhouse/insect hotel. Maybe rooftiles.

I would want to put plants or bird food in it.

Other insights/conclusions?

Conclusion

the more natural appearance the better for the reef.

Rain reef interesting

would spend max 100 euros

if only function is as art piece that is maybe good for climate.

would spend more money if I can tap rain water from the reef to use for my plants

width not bigger then 20x20 or 30x30. Height does not matter.

Participant 1

insights for citizen science/experiment

Good quote

Insight

I am really trying to get my house more green and this reef really fits with it.

Talking about it with colleageas and friends

Hassle putting meters in -> place small thermometer/hygrometer inside standard

Some places are tricky to place the reef with cats that might bump in to it.

Conclusion

It helps if the goal of the research is in line with their own personal goals/values.

With the growing light the growth of the algae goes very fast.

Citizen science can inspire personal behaviour changes for participants and surrounding.

insights human nature connection Reef

. Also sharing it with colleagues and friends, every day people ask how Griet is doing, already greener?.

I always look also how they are doing every night, and I say good night.

I really enjoy doing it, making something from nothing is always very nice.

Not have a big bond with it, but will maybe come more when more plants will grow on it

If it becomes grey/yellow I will look into what I can do to influence that there will come more life on it.

Insight

Called the Rief Griet, *from the scientist Grietitulator, and is a non-binary name.*

I do measurements in the mornings and water + good night check in the eveing, check on it frequently

Happy to see progress/ growth

Looking forward to future growth/development of the reef.

Will keep an eye on the state of the reef in garden and intervene if necessary.

Want to help the reef kickstart by putting moss/yogurt/alga e on it.

Conclusion

Giving the reef a name creates more of a personal connection.

Sharing conversations about it with importans people makes it more fun

Very involved and curious towards the reef. (Has to do with personal values most likely).

The more the reef develops and changes over time, the more likely a bond will develop.

There is a longing to help/ control the growth.

insights human nature connection in general

All small efforts help in making the city green and liveable.

I walk a lot with the dog in nature, helps me to be more in nature. The dog has a different perspective and makes me see different things

Reef inspired me to make garden more biodiverse/green.

when I saw the advertisement I decided to make a "sedum" roof in my garden so that the reef would have a pretty place to be placed on

Insight

Puts a lot of effort into making her small garden as green and biodiverse nature as possible.

In the centre people always say there is no space for a green garden, but there is, you should put effort in it.

Dog brings me closer to nature.

Me doing this experiment inspired my parents to also want to work on their garden.

Conclusion

Feels like the reef can help make a small garden more biodiverse and green.

Feels like it is her responsibility to help make the innercity a bit more green.

Animals make people feel closer to nature (not only plants/green)

Very self informed about good plants and ways to make house greener, because of personal benefits (less heat) as well as better for the environment.

The reef/experiment inspired active changes to garden for more biodiversity.

Next to the advantages for me I think it is just necessary for the environment. I get very sad when I only see stone around me and no green.

General insights for Urban Reef

Insight

The reef looks organic: almost like no end/beginning. (Which she likes)

Wants to adjust shape to own garden.

Place another kind of reef shape on roof terrace then in garden. Mainly due to difference in amount of space for it.

Maybe adjust shape of reef for cats to climb in.

Other insights/conclusions?

I also do not have that much space so if I want to put something in my garden it needs to be pretty because you are looking at it all day.

I would spend around 200-500 euros on a rain reef.

Needs to be pretty to look at.

Conclusion

That I can place it along my walls and think of how water will flow from the top of the rainpipe down to the garden and around, kind of in a rollercoaster shape.

Preffered shape depends on available space for it.

wants to take into account pets or other local animals in design

Appendix G - Informed Consent

Consent formulier – Urban Reef Afstudeer Onderzoek

Dit onderzoek wordt uitgevoerd als onderdeel van het Thesis Project van Dawn Verkerk in samenwerking met Urban Reef, als deel van de MSc Integrated Product Design aan de TU Delft.

Contact persoon: Dawn, +31 [redacted]

Toestemmingsverklaring participant

Ik neem vrijwillig deel aan dit onderzoek.

Ik erken dat ik vooraf voldoende informatie en uitleg heb gekregen over dit onderzoek en al mijn vragen zijn naar voldoening beantwoord. Ik heb de tijd gekregen die ik nodig had om in te stemmen met de deelname. Op elk moment kan ik vragen stellen met betrekking tot het onderzoek.

Mij is bekend dat dit onderzoek bestaat uit:

I. Twee groep sessies
II. Experiment met Chlorella Algen
III. Persoonlijk Interview

Ik ben mij ervan bewust dat tijdens het onderzoek gegevens worden verzameld in de vorm van data, aantekeningen, foto's, video's en/of geluidsopnames. Ik geef toestemming voor het verzamelen van deze gegevens en het maken van geluidsopnames, foto's en video opnames tijdens het onderzoek. Gegevens zullen geanonimiseerd worden verwerkt en geanalyseerd (zonder naam of andere identificeerbare informatie). Deze gegevens zijn voor het onderzoeksteam, TU Delft begeleiders en Urban Reef beschikbaar. De foto's, video's en/of geluidsopnames zullen worden gebruikt ter ondersteuning van het analyseren van verzamelde gegevens. Video opnames en foto's worden gebruikt ter illustratie van onderzoeksbevindingen in publicaties en presentaties over het project.

Ik geef toestemming voor het gebruik van foto's en video opnames van mijn deelname:
(selecteer wat van toepassing is)

- ❑ waarin ik herkenbaar ben voor publicaties en presentaties over het project.
- ❑ waarin ik niet herkenbaar ben voor publicaties en presentaties over het project.
- ❑ enkel voor data analyse doeleinden en niet voor publicaties en presentaties over het project.

Ik geef toestemming om gegevens nog maximaal 5 jaar na afloop van dit onderzoek te bewaren en te gebruiken voor onderwijs- en onderzoeksdoeleinden.

Ik erken dat er geen financiële compensatie gegeven wordt voor deelname aan het onderzoek.

De onderzoekers nemen de momenteel geldende COVID-19 richtlijnen in acht. Als deelnemer aan dit onderzoek zal ik de COVID-19 maatregelen respecteren en de aanwijzingen hierover van de onderzoekers opvolgen.

Met mijn handtekening bevestig ik dat ik de informatie over het onderzoek heb gelezen en dat ik de aard van mijn deelname heb begrepen. Ik begrijp dat ik mijn deelname aan het onderzoek op elk moment kan intrekken of kan stoppen. Ik begrijp dat ik niet verplicht ben om vragen te beantwoorden die ik niet wil beantwoorden en dat ik dit kan aangeven bij het onderzoeksteam. Een kopie van deze toestemmingsverklaring zal aan mij worden gegeven.

_____ _____

Achternaam Voornaam

___ / ___ / 2023 _____

Datum (dd/mm/jjjj) Handtekening

Appendix H - Ethics Checklist

Delft University of Technology
HUMAN RESEARCH ETHICS
CHECKLIST FOR HUMAN RESEARCH
(Version January 2022)

IMPORTANT NOTES ON PREPARING THIS CHECKLIST

1. An HREC application should be submitted for every research study that involves human participants (as Research Subjects) carried out by TU Delft researchers
2. Your HREC application should be submitted and approved **before** potential participants are approached to take part in your study
3. All submissions from Master's Students for their research thesis need approval from the relevant Responsible Researcher
4. The Responsible Researcher must indicate their approval of the completeness and quality of the submission by signing and dating this form OR by providing approval to the corresponding researcher via email (included as a PDF with the full HREC submission)
5. There are various aspects of human research compliance which fall outside of the remit of the HREC, but which must be in place to obtain HREC approval. These often require input from internal or external experts such as Faculty Data Stewards, Faculty HSE advisors, the TU Delft Privacy Team or external Medical research partners.
6. You can find detailed guidance on completing your HREC application here
7. Please note that incomplete submissions (whether in terms of documentation or the information provided therein) will be returned for completion **prior to any assessment**
8. If you have any feedback on any aspect of the HREC approval tools and/or process you can leave your comments here

I. Applicant Information

PROJECT TITLE:	Citizen science test with Algae for Urban Reef
Research period: *Over what period of time will this specific part of the research take place*	6-13th of March
Faculty:	Industrial Design Engineering
Department:	Sustanable Design Engineering
Type of the research project: *(Bachelor's, Master's, DreamTeam, PhD, PostDoc, Senior Researcher, Organisational etc.)*	Master's Thesis
Funder of research: *(EU, NWO, TUD, other – in which case please elaborate)*	Urban Reef (https://www.urbanreef.nl/)
Name of Corresponding Researcher: *(If different from the Responsible Researcher)*	Dawn Verkerk
E-mail Corresponding Researcher: *(If different from the Responsible Researcher)*	[redacted]
Position of Corresponding Researcher: *(Masters, DreamTeam, PhD, PostDoc, Assistant/ Associate/ Full Professor)*	Masters
Name of Responsible Researcher: ***Note:** all student work must have a named Responsible Researcher to approve, sign and submit this application*	Elvin Karana
E-mail of Responsible Researcher: *Please ensure that an institutional email address (**no Gmail, Yahoo, etc.**) is used for all project documentation/ communications including Informed Consent materials*	[redacted]
Position of Responsible Researcher : *(PhD, PostDoc, Associate/ Assistant/ Full Professor)*	Full Proffesor

II. Research Overview

***NOTE:** You can find more guidance on completing this checklist here*

a) Please summarise your research very briefly (100-200 words)

What are you looking into, who is involved, how many participants there will be, how they will be recruited and what are they expected to do?

Add your text here – (please avoid jargon and abbrevations)
I am researching the effect of citizen science on the human nature connection with an algae (chlorella vulgaris) experiment on urban reefs (3d pinted ceramic sculptures that are bioreceptive). A total of 5 participants of local Delft citizens will be asked to ''take care of the reef and algae'' over a period of 1 week. They will be recruited through the personal network of Dawn Verkerk. The participants will spray the reef with water & nutrients every day. They will be asked to actively pay attention to how the algae will grow and develop and make pictures of the reef everyday as well as write down some temperature/humidity/light measurement and observations. Before and after the experiment the participants will be asked some personal questions and to fill in the nature relatedness scale. The research is funded by Urban Reef and Urban Reef as well as the TU Delft will have access to the data.

b) **If your application is an additional project** related to an existing approved HREC submission, please provide a brief explanation including the existing relevant HREC submission number/s.

Add your text here – (please avoid jargon and abbrevations)
na

c) **If your application is a simple extension of, or amendment to,** an existing approved HREC submission, you can simply submit an HREC Amendment Form as a submission through LabServant.

III. Risk Assessment and Mitigation Plan

***NOTE:** You can find more guidance on completing this checklist here*

Please complete the following table in full for all points to which your answer is "yes". Bear in mind that the vast majority of projects involving human participants as Research Subjects also involve the collection of **Personally Identifiable Information (PII)** and/or **Personally Identifiable Research Data (PIRD)** which may pose potential risks to participants as detailed in Section G: Data Processing and Privacy below.

To ensure alighment between your risk assessment, data management and what you agree with your Research Subjects you can use the last two columns in the table below to refer to specific points in your Data Management Plan (DMP) and Informed Consent Form (ICF) – **but this is not compulsory**.

It's worth noting that **you're much more likely to need to resubmit your application if you neglect to identify potential risks**, than if you identify a potential risk and demonstrate how you will mitigate it. If necessary, the HREC will always work with you and colleagues in the Privacy Team and Data Management Services to see how, if at all possible, your research can be conducted.

				If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
	Yes	**No**		**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
ISSUE							
A: Partners and collaboration							
1. Will the research be carried out in collaboration with additional organisational partners such as: • One or more collaborating research and/or commercial organisations • Either a research, or a work experience internship provider[1] *[1] If yes, please include the graduation agreement in this application*	x			**Low Risk:** The research is in assignment of Urban Reef. One risk can be that they might intervene with the research or halt the research entirely due to the use of the reefs.	To mitigate this I have reviewed the test plan together with my contact from Urban reef. I will also keep them updated of the progress throughout the testing period.		
2. Is this research dependent on a Data Transfer or Processing Agreement with a collaborating partner or third party supplier? *If yes please provide a copy of the signed DTA/DPA*		x					
3. Has this research been approved by another (external) research ethics committee (e.g.: HREC and/or MREC/METC)? *If yes, please provide a copy of the approval (if possible) and summarise any key points in your Risk Management section below*		x					
B: Location							

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
4. Will the research take place in a country or countries, other than the Netherlands, within the EU?		x				
5. Will the research take place in a country or countries outside the EU?		x				
6. Will the research take place in a place/region or of higher risk – including known dangerous locations (in any country) or locations with non-democratic regimes?		x				
C: Participants						
7. Will the study involve participants who **may** be vulnerable and possibly (legally) unable to give informed consent? (e.g., children below the legal age for giving consent, people with learning difficulties, people living in care or nursing homes,).		x				
8. Will the study involve participants who **may** be vulnerable under specific circumstances and in specific contexts, such as victims and witnesses of violence, including domestic violence; sex workers; members of minority groups, refugees, irregular migrants or dissidents?		x				
9. Are the participants, outside the context of the research, in a dependent or subordinate position to the investigator (such as own children, own students or employees of either TU Delft and/or a collaborating partner organisation)? *It is essential that you safeguard against possible adverse consequences of this situation (such as allowing a student's failure to participate to your satisfaction to affect your evaluation of their coursework).*		x				
10. Is there a high possibility of re-identification for your participants? (e.g., do they have a very specialist job of which there are only a small number in a given country, are they members of a small community, or employees from a partner company collaborating in the research? Or are they one of only a handful of (expert) participants in the study?	x		**Low Risk:** There is only a small group of participants in the study.	All of the paticipants will sign a consent form and they are personal acquaintances which agree to be part of a small test group that can be possibly re-identified.		
D: Recruiting Participants						
11. Will your participants be recruited through your own, professional, channels such as conference attendance lists, or through specific network/s such as self-help groups		x				
12. Will the participants be recruited or accessed in the longer term by a (legal or customary) gatekeeper? (e.g., an adult professional working with children; a community leader or family member who has this customary role – within or outside the EU; the data producer of a long-term cohort study)		x				

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
13. Will you be recruiting your participants through a crowd-sourcing service and/or involve a third party data-gathering service, such as a survey platform?		x				
14. Will you be offering any financial, or other, remuneration to participants, and might this induce or bias participation?		x				
E: Subject Matter *Research related to medical questions/health may require special attention. See also the website of the CCMO before contacting the HREC.*						
15. Will your research involve any of the following: • Medical research and/or clinical trials • Invasive sampling and/or medical imaging • Medical and *In Vitro Diagnostic Medical* Devices Research		x				
16. Will drugs, placebos, or other substances (e.g., drinks, foods, food or drink constituents, dietary supplements) be administered to the study participants? *If yes see here to determine whether medical ethical approval is required*		x				
17. Will blood or tissue samples be obtained from participants? *If yes see here to determine whether medical ethical approval is required*		x				
18. Does the study risk causing psychological stress or anxiety beyond that normally encountered by the participants in their life outside research?		x				
19. Will the study involve discussion of personal sensitive data which could put participants at increased legal, financial, reputational, security or other risk? (e.g., financial data, location data, data relating to children or other vulnerable groups) *Definitions of sensitive personal data, and special cases are provided on the TUD Privacy Team website.*		x				
20. Will the study involve disclosing commercially or professionally sensitive, or confidential information? (e.g., relating to decision-making processes or business strategies which might, for example, be of interest to competitors)		x				
21. Has your study been identified by the TU Delft Privacy Team as requiring a Data Processing Impact Assessment (DPIA)? *If yes please attach the advice/ approval from the Privacy Team to this application*		x				
22. Does your research investigate causes or areas of conflict? *If yes please confirm that your fieldwork has been discussed with the appropriate safety/security advisors and approved by your Department/Faculty.*		x				

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
23. Does your research involve observing illegal activities or data processed or provided by authorities responsible for preventing, investigating, detecting or prosecuting criminal offences *If so please confirm that your work has been discussed with the appropriate legal advisors and approved by your Department/Faculty.*		x				
F: Research Methods						
24. Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g., covert observation of people in non-public places).		x				
25. Will the study involve actively deceiving the participants? (For example, will participants be deliberately falsely informed, will information be withheld from them or will they be misled in such a way that they are likely to object or show unease when debriefed about the study).		x				
26. Is pain or more than mild discomfort likely to result from the study? And/or could your research activity cause an accident involving (non-) participants?		x				
27. Will the experiment involve the use of devices that are not 'CE' certified? *Only, if 'yes': continue with the following questions:*		x				
• Was the device built in-house?		x				
• Was it inspected by a safety expert at TU Delft? *If yes, please provide a signed device report*		x				
• If it was not built in-house and not CE-certified, was it inspected by some other, qualified authority in safety and approved? *If yes, please provide records of the inspection*		x				
28. Will your research involve face-to-face encounters with your participants and if so how will you assess and address Covid considerations?	x		**Low Risk:** The interview sessions will be held face to face as well as the delivering and picking up of the reefs.	There will be a minimum distance of 1,5 meter between the interviewer and the participant and the ventilation of the room will be checked. The researcher will conduct a COVID selftest before the interviews.		
29. Will your research involve **either:** a) "big data", combined datasets, new data-gathering or new data-merging techniques which might lead to re-identification of your participants **and/or** b) artificial intelligence or algorithm training where, for example biased datasets could lead to biased outcomes?		x				
G: Data Processing and Privacy						
30. Will the research involve collecting, processing and/or storing any directly identifiable PII (Personally Identifiable Information) including name or email		x				

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
address that will be used for administrative purposes only? (eg: obtaining Informed Consent or disbursing remuneration)						
31. Will the research involve collecting, processing and/or storing any directly or indirectly identifiable PIRD (Personally Identifiable Research Data) including videos, pictures, IP address, gender, age etc and **what other Personal Research Data** (including personal or professional views) will you be collecting?	x		**Low Risk:** Some personal pictures will be made of participants and by the participants of the reef in their house, these can be included in the report/presentation. Participants could not consent to the use of their pictures in publications.	Particpants will explicitly state in a consent form whether they agree to the use of recognizable, non-recognizable or no images in the publication.		
32. Will this research involve collecting data from the internet, social media and/or publicly available datasets which have been originally contributed by human participants		x				
33. Will your research findings be published in one or more forms in the public domain, as e.g., Masters thesis, journal publication, conference presentation or wider public dissemination?	X		**Low Risk:** It will be published as part of the Master Thesis on the Repository of TU Delft.	The participants will be informed of the publication by the researcher and it will be stated in the consent form. All of the data will be anonymous except for the recognizable images that they have given consent for.		
34. Will your research data be archived for re-use and/or teaching in an open, private or semi-open archive?		x				

H: More on Informed Consent and Data Management

NOTE: You can find guidance and templates for preparing your Informed Consent materials) here

Your research involves human participants as Research Subjects if you are recruiting them or actively involving or influencing, manipulating or directing them in any way in your research activities. This means you must seek informed consent and agree/ implement appropriate safeguards regardless of whether you are collecting any PIRD.

Where you are also collecting PIRD, and using Informed Consent as the legal basis for your research, you need to also make sure that your IC materials are clear on any related risks and the mitigating measures you will take – including through responsible data management.

Got a comment on this checklist or the HREC process? You can leave your comments here

IV. Signature/s

Please note that by signing this checklist list as the sole, or Responsible, researcher you are providing approval of the completeness and quality of the submission, as well as confirming alignment between GDPR, Data Management and Informed Consent requirements.

Name of Corresponding Researcher (if different from the Responsible Researcher) (print)

Signature of Corresponding Researcher: [redacted]

Date: 20-02-2023

Name of Responsible Researcher (print)

Signature (or upload consent by mail) Responsible Researcher: Prof. dr. Elvin Karana

Date: 20.Feb.2023 [redacted]

V. Completing your HREC application

Please use the following list to check that you have provided all relevant documentation

Required:

- **Always:** This completed HREC checklist
- **Always:** A data management plan (reviewed, where necessary, by a data-steward)
- **Usually:** A complete Informed Consent form (including Participant Information) and/or Opening Statement (for online consent)

Please also attach any of the following, if relevant to your research:

Document or approval	Contact/s
Full Research Ethics Application	After the assessment of your initial application **HREC will let you know if and when you need to submit additional information**
Signed, valid Device Report	Your Faculty HSE advisor
Ethics approval from an external Medical Committee	TU Delft Policy Advisor, Medical (Devices) Research
Ethics approval from an external Research Ethics Committee	Please append, if possible, with your submission
Approved Data Transfer or Data Processing Agreement	Your Faculty Data Steward and/or TU Delft Privacy Team
Approved Graduation Agreement	Your Master's thesis supervisor
Data Processing Impact Assessment (DPIA)	TU Delft Privacy Team
Other specific requirement	Please reference/explain in your checklist and append with your submission

Appendix I - Data Management Plan

Urban Reef Nature connectedness through citizen science

0. Administrative questions

1. Name of data management support staff consulted during the preparation of this plan.

My faculty data steward, Jeff Love, has been asked to review this DMP on 17-02-2023

2. Date of consultation with support staff.

2023-02-17

I. Data description and collection or re-use of existing data

3. Provide a general description of the type of data you will be working with, including any re-used data:

Type of data	File format(s)	How will data be collected (for re-used data: source and terms of use)?	Purpose of processing	Storage location	Who will have access to the data
Quantative interview data	.xlsx and PDF	Microsoft form	Calculation of nature relatedness index and wellbeing index	OneDrive	Main researcher
Gender, Age, Level of education, Area growing up, Household type	.xlsx and PDF	Microsoft form	To make appropriate conclusions/correlations.	OneDrive	Main researcher
Audio recording	.mp3	Phone recording	To gather other user insights	OneDrive, deleted after processing	Main researcher
Interview notes	.docx	Written in word document	To gather other user insights	OneDrive, deleted after processing	Main researcher
Data on temperature, humidity, light and other observations around the reef	.xlsx and PDF	Written on paper and written in excel	To gather experimental data	OneDrive & Google Drive	Main researcher, Urban Reef
Pictures of the reefs	.xlsx and PDF	Microsoft form	To measure the growth of the algae & verify active participation	OneDrive & Google Drive	Main researcher, Urban Reef

4. How much data storage will you require during the project lifetime?

- < 250 GB

II. Documentation and data quality

5. What documentation will accompany data?

- Methodology of data collection

III. Storage and backup during research process

6. Where will the data (and code, if applicable) be stored and backed-up during the project lifetime?

- Another storage system - please explain below, including provided security measures
- OneDrive

Part of the Data (measurements and pictures of the reefs) will be uploaded to the Google drive of Urban Reef which is only accessible to Urban Reef employees.

IV. Legal and ethical requirements, codes of conduct

7. Does your research involve human subjects or 3rd party datasets collected from human participants?

- Yes

8A. Will you work with personal data? (information about an identified or identifiable natural person)

If you are not sure which option to select, ask your Faculty Data Steward for advice. You can also check with the privacy website or contact the privacy team: privacy-tud@tudelft.nl

- Yes

I will ask for their ''Gender, Age, Level of education, Area growing up, Household type'' as this can be relevant to the nature relatedness index as well as well-being index.

8B. Will you work with any other types of confidential or classified data or code as listed below? (tick all that apply)

If you are not sure which option to select, ask your Faculty Data Steward for advice.

- No, I will not work with any confidential or classified data/code

9. How will ownership of the data and intellectual property rights to the data be managed?

For projects involving commercially-sensitive research or research involving third parties, seek advice of your Faculty Contract Manager when answering this question. If this is not the case, you can use the example below.

The datasets underlying the published papers will be publicly released following the TU Delft Research Data Framework Policy. During the active phase of research, the project leader from TU Delft will oversee the access rights to data (and other outputs), as well as any requests for access from external parties. They will be released publicly no later than at the time of publication of corresponding research papers.

10. Which personal data will you process? Tick all that apply

- Photographs, video materials, performance appraisals or student results
- Signed consent forms
- Special categories of personal data (specify which): race, ethnicity, criminal offence data, political beliefs, union membership, religion, sex life, health data, biometric or genetic data

- Gender, date of birth and/or age

I will ask for Level of education, household type and are of growing up.

11. Please list the categories of data subjects

General public in Delft area.

12. Will you be sharing personal data with individuals/organisations outside of the EEA (European Economic Area)?

- No

15. What is the legal ground for personal data processing?

- Informed consent

16. Please describe the informed consent procedure you will follow:

All study participants will be asked for their written consent for taking part in the study and for data processing before the start of the interview.

17. Where will you store the signed consent forms?

- Same storage solutions as explained in question 6

18. Does the processing of the personal data result in a high risk to the data subjects?

If the processing of the personal data results in a high risk to the data subjects, it is required to perform a Data Protection Impact Assessment (DPIA). In order to determine if there is a high risk for the data subjects, please check if any of the options below that are applicable to the processing of the personal data during your research (check all that apply).
If two or more of the options listed below apply, you will have to complete the DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to receive support with DPIA.
If only one of the options listed below applies, your project might need a DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to get advice as to whether DPIA is necessary.
If you have any additional comments, please add them in the box below.

- None of the above applies

22. What will happen with personal research data after the end of the research project?

- Anonymised or aggregated data will be shared with others

Data from the research will be used by Urban Reef to support future research with Algae and/or citizen science.

25. Will your study participants be asked for their consent for data sharing?

- Yes, in consent form - please explain below what you will do with data from participants who did not consent to data sharing

In the case that a participant does not consent to data sharing their image will not be used in any publication of the research results.

V. Data sharing and long-term preservation

27. Apart from personal data mentioned in question 22, will any other data be publicly shared?

- All other non-personal data (and code) underlying published articles / reports / theses

29. How will you share research data (and code), including the one mentioned in question 22?

- All anonymised or aggregated data, and/or all other non-personal data will be uploaded to 4TU.ResearchData with public access

30. How much of your data will be shared in a research data repository?

- < 100 GB

31. When will the data (or code) be shared?

- At the end of the research project

32. Under what licence will be the data/code released?

- CC0

VI. Data management responsibilities and resources

33. Is TU Delft the lead institution for this project?

- Yes, leading the collaboration - please provide details of the type of collaboration and the involved parties below

Urban Reef is the project client, a representative is part of the supervisory team. They provide reefs and funding for the research and the results will be shared with them.

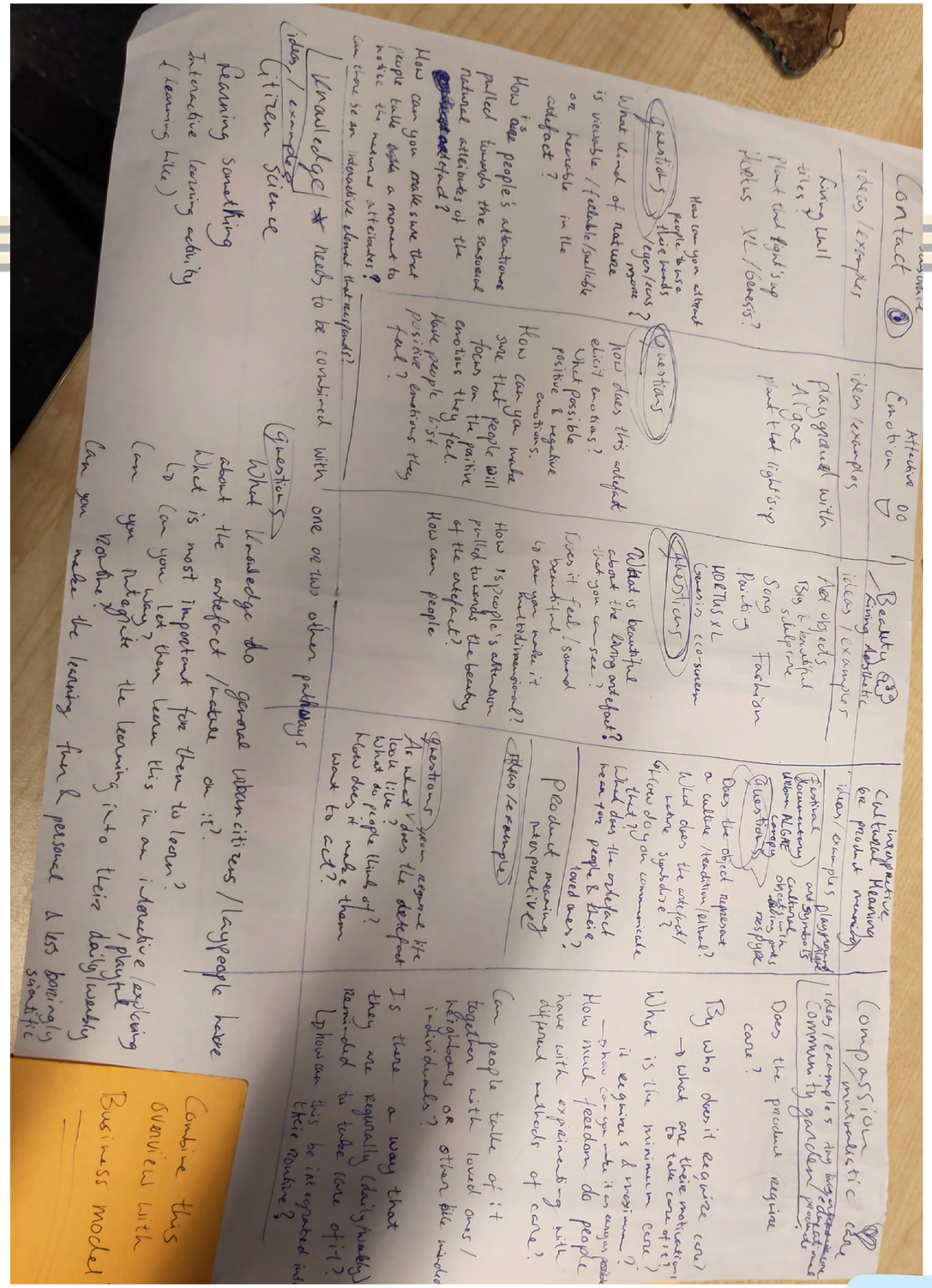
34. If you leave TU Delft (or are unavailable), who is going to be responsible for the data resulting from this project?

The chair of this master thesis project, prof. dr. Elvin Karana

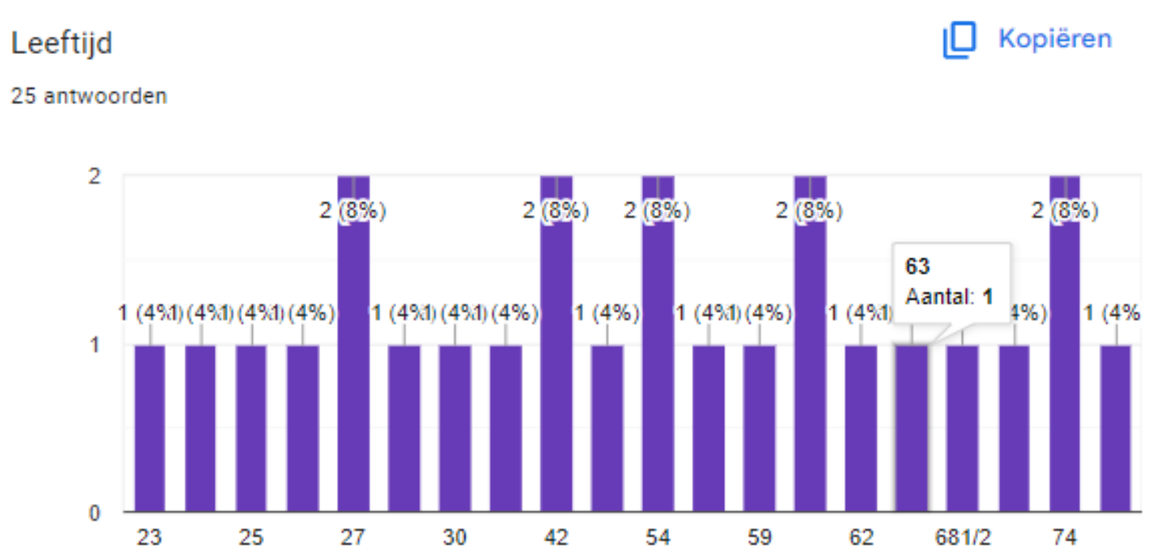
35. What resources (for example financial and time) will be dedicated to data management and ensuring that data will be FAIR (Findable, Accessible, Interoperable, Re-usable)?

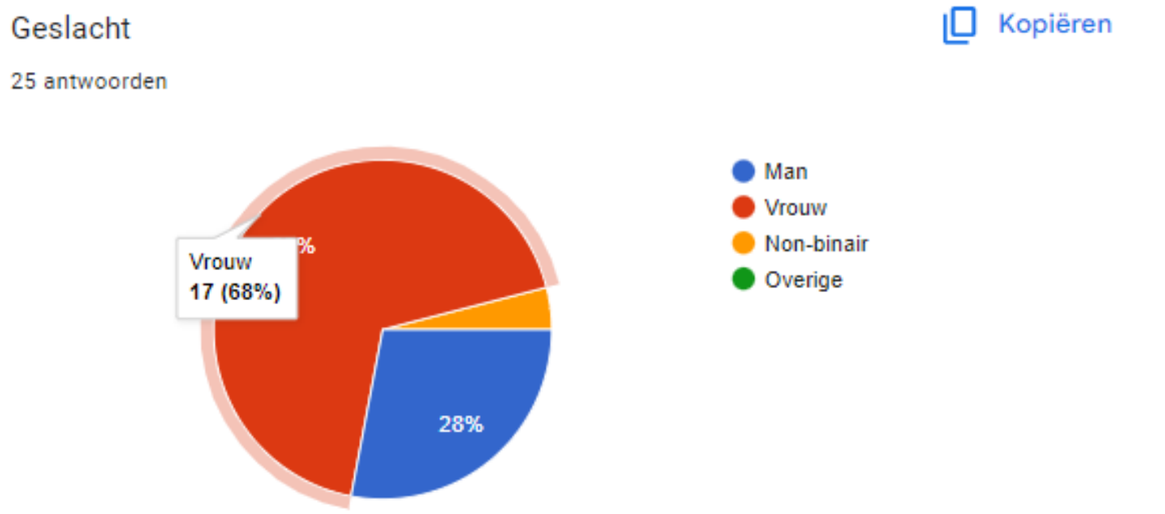
4TU.ResearchData is able to archive 1TB of data per researcher per year free of charge for all TU Delft researchers. We do not expect to exceed this and therefore there are no additional costs of long term preservation.

Appendix J - First draft Design Guidelines



Appendix K - Results user evaluation concepts

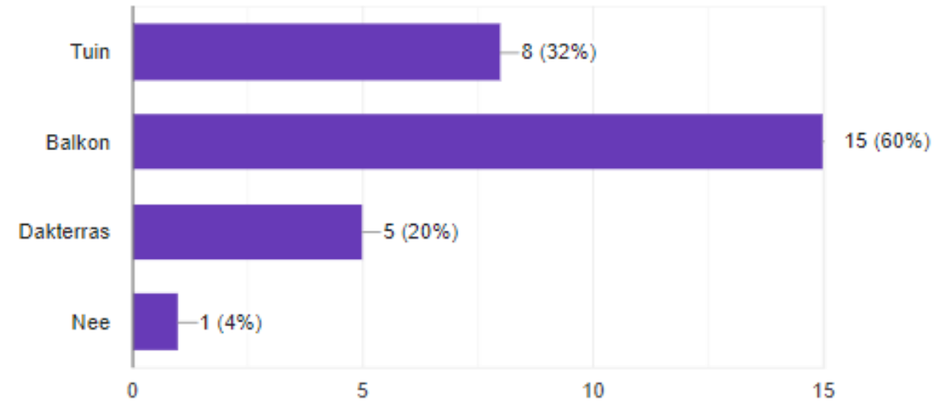




Heeft u een tuin/balkon/dakterras?

Kopiëren

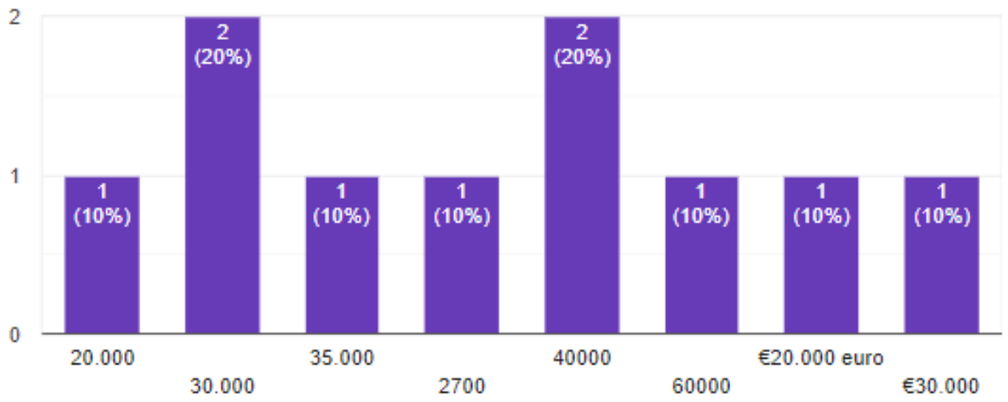
25 antwoorden



Wat is het netto jaarlijks inkomen van uw huishouden?

Kopiëren

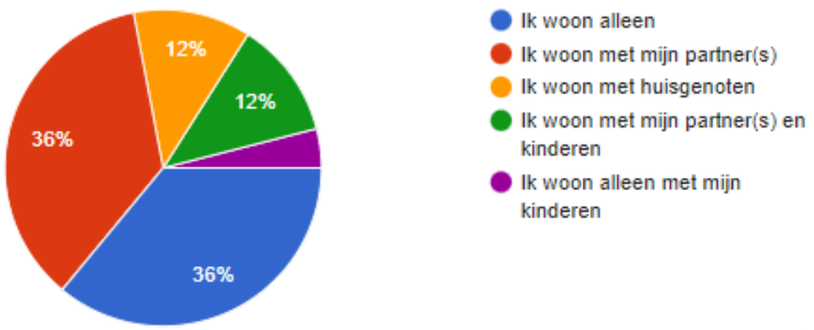
10 antwoorden



Wat is de samenstelling van uw huishouden?

Kopiëren

25 antwoorden



Concept A

Wat vind u van het concept?

25 antwoorden

Leuk! duidelijk concept en motiverend.
Leuk idee, maar mussen en andere vogels zitten wel liefst iets uit elkaar. Verder ivm de tijgermug is het niet raadzaam om water plekken te hebben met stilstaand water omdat de mug daarin eitjes legt
Lijkt op een Hart
Interessant
Het lijkt een vogelhuisje. Waarom zou ik het water moeten geven? Is het voor de hygiëne voor het beestje wel interessant om water en voedsel in het ontwerp te hebben?
Ziet er mooi en artistiek uit.
Leuk. Wel checken bij vogelexperts of de vorm, grotte van gat etc. geschikt is
Grappig een veredelt vogelhuisje
Het is een rif, dus ik neem aan dat het aan een verticale wand is opgehangen, maar ik heb geen idee hoe groot het is en het ontgsst me nu ook nog een beetje voor wie het bedoeld is en wat de prijs en dergelijke zal zijn
cute
Prima mooi initiatief
Goed verzonnen.
Er zijn veel vogeltjes in de buurt, dit is een leuke manier om die meer te horen in de ochtend.
Prima voor tuin niet op t balkon
Grappig ontwerp
Ik vind meer natuur en wild leuk, maar zou nooit dagboeken bijhouden. Ben nauwelijks thuis.
Geweldig
Ik kan me er niet zoveel bij voorstellen.
Heel erg gaaf, zout zo bestellen en ophangen!
Grappig goed vedaxht
Het rif ziet er niet zo aantrekkelijk uit. Wel leuk idee. Om er mee bezig te zijn is leuk, de administratie er om heen minder leuk.
Interessant en vernieuwend
Leuk
De afbeelding is nogal onscherp dus niet helemaal goed te zien wat het inhoudt. Het probleem wat is met de mussen zie is dat ik dit op mijn balkon neer zou zetten op een plek waar ik liever geen vogels wil. Als ik het aan mijn balkon kan hangen zou het geschikter zijn. ook denk ik dat dit een troep zal worden met vogelzaad, poep en planten. Daarnaast zou ik niet willen dat dit kraaien of meeuwen aantrekt.
Geen idee wat het woord rif betekend....verwarrend

Wat vind u goed aan het concept?

25 antwoorden

Simpel en duidelijke aanpak. Alle informatie wordt duidelijk aangegeven. Stappen zijn simpel en de checklist geeft overzicht. Je hoeft niet na te denken over wat je voor verzorging moet kopen, daar is al aan gedacht. klinkt als een laagdrempelige manier om voor mussen en organismen een fijne omgeving te creëren.
Leuk idee, ik zou het is een schutting verwerken waar ook struikgewas tegenaan groeit(mus is struik vogel en struikgewas is schaats in stads tuinen
De Vorm
Interactief, trekt je het tuinieren in
Online dagboek is leuk. Draagt het ook bij aan iets groters? Natuurmonumenten ofzo
Het is compact en makkelijk te onderhouden.
Interactief. Je blijft ermee bezig. vooral leuk met kinderen, of juist voor ouderen.
Dat het biodiversiteit stimuleert
dat weet ik eigenlijk niet, want het is me nog niet helemaal duidelijk wat beoogd wordt
Verbind zowel vogels als groen
Meer natuur in de stad!
Er is goed over nagedacht, vooral het bestellen van een zorgpakket
Trekt vogeltjes aan, op een manier die anders is dan normale huisjes of zakjes voer.
Tuin laten verwilderen op sommige plekken, makkelijk water geven. Fijn om de mussen weer terug te zien
Mooi om na te denken om vogels actief een plek te geven in de stad
Verwildering en natuur meer de ruimte geven.
Dat het de stadsmens meer naar de natuur brengt en de natuur meer naar de stad.
Het ziet er vriendelijk uit en lijkt makkelijk in het gebruik.
Plek voor mussen maar ook voor plantjes. Meerdere doeleinden
Vooral geschikt voor balkons.
Meer mussen, lekker bezig in de tuin.
Integratie van verzorging voor het reef + tips om het habitat geschikt te maken
“Planten rond rif is een goed idee
vogeltjes zijn leuk”
Interactie met dieren. Ik hou er zelf van om de natuur in een stad een handje te helpen
Ik denk dat het mogelijk natuur rondom mijn balkon kan stimuleren?

Wat vind u niet zo goed aan het concept? Hoe zou u dit aanpassen?

25 antwoorden

Dit ligt meer aan het feit dat het een concept is, maar de plekken waar water of voedsel kunnen worden toegevoegd zijn wel te zien in de afbeelding, maar kan nog niet zo goed visualiseren hoe dat in de realiteit zou zijn. Maar denk niet dat dit uitmaakt, dat spreekt tegen die tijd wel voor zich.
Aanpassing ; het moet open kunnen om het oude vogel afval er uit te halen ivm duurzaamheid en het gebruik voor het volgende nest
De gaten is groter , zodat de mussen beter bij het water kunnen komen.
Geen opmerkingen
Het lijkt net een kikker. Moet je een vogelhuisje niet zo veel mogelijk met rust laten? Door er water over te gieten en voedsel te geven. Lijkt me geen rust voor het nestje erbinnen.
Ik vind het oké zó.
Ik zou ook de beplanting in de tuin of op balkon meenemen. Zodat vogels genoeg eten uit de tuin of omgeving kunnen halen.
Ik zou de vragen meer uitbreiden bijvoorbeeld welke soort mus man/vrouw en of er wordt gebroed en vanaf wanneer en of er jongen zijn en wanneer ze uitvliegen. En dat dit gemeld wordt op websites waar die voor bedoelt zijn zoals bijvoorbeeld waarneming.nl zodat de dieren en tijden van gedrag ook daadwerkelijk gemonitoord kunnen worden en natuurorganisaties hier echt iets aan hebben. Je zou hier een handleiding voor kunnen schrijven.
het minst aantrekkelijke vind ik om voedsel direct beschikbaar te stellen, het lijkt me nog het best dat de musjes hun eigen voedsel bijeen scharrelen, en dat we wel kunnen zorgen dat dit op een of andere manier op natuurlijke wijze beschikbaar is/komt
-
Men moet er tijd insteken, en dat kan een puntje zijn
Ik ben bang dat mensen in deze hectische tijd geen dagboek bij willen en zullen houden.
Zorg dagboekje zie ik mezelf niet zo snel gebruiken, misschien minder prominent op de pagina en als apparte form beschikbaar stellen?
Geen idee
Ik vind het wel goed
Het dagboek, geen idee waarvoor ik dat doe. Ik wil dat ik elk weekend lekker wat kan klussen of toevoegen, en dan alles z’n gang laat gaan
Dat zou ik niet weten...
De vorm spreekt mij niet zo aan
Niks
Zou ik niet aankopen als ik een echte groene tuin tuin heb. Dwz bijna geen tegels o.l.d
Administratie, misschien makkelijker in een app.
Voederen bij de nesten. Dit is niet natuurlijk voor vogels (zij halen hun voer wat verderop en brengen dat terug naar het nest), en kan ook ongedierte aantrekken dat mogelijk slecht is voor de eieren/jonge vogels.
“niet mooi
gezamelijk dagboek is niet realistisch
Vogelvoer toevoegen lijkt lastig”
het aspect dat het voor vogels (mussen) is.
Ziet er uit als veel gedoe.

Concept B

Wat vind u van het concept?

25 antwoorden

heel goed!
Heel leuk
Duidelijk
Mooi/interessant
Goed dat je iets kunt kiezen wat in je tuin past. Bepaalde kanten van een tuin is interessant voor vleermuizen terwijl andere interessant zijn voor musjes.
Erg goed met verrassende mogelijkheden.
Leuk! Ik zou ze alleen allemaal willen :)
Ik weet het niet ik lees te weinig over specifieke functies en toegevoegde waarde ik vind het vooral iets estetisch.
Het klinkt aantrekkelijk dat je een en ander kan samenstellen naar eigen smaak, maar ik heb nog even wat moeite om me het VR gedeelte eigen te maken;
heel cool
Goed initiatief
Voor echte natuurliefhebbers is het een prima idee.
Erg fijn dat er keuze is rond het type en de formaat, dit geeft flexibiliteit in gebruik en maakt het ook makkelijker om b.v. kado te doen.
Goed om verschillende keuzes te hebben. Fijn dat je ook de impact kan zien
Super leuk
Ik mis uitleg over de gevolgen per rif en vind Vr onwijs overbodig in deze situatie. Een technologie die hier misplaatst lijkt.
Aantrekkelijk
Klinkt heel geavanceerd...
Ik zou alle 3 de reefs willen hebben, echt geweldig uitgewerkt!
Aanpassingsmogelijkheden heel goed idee.
Leuk idee. Veel is mogelijk.
Cool, leuk dat je het zelf kunt samenstellen, dan voelt het ook meer 'eigen'.
Leuk!
Ik vind het leuk om iets te maken wat ik "zelf" gemaakt heb
Nogmaals wat is rif? Waar kan ik het plaatsen? wat is het doel? vaag

Wat vind u goed aan het concept?

25 antwoorden

Het is fijn dat er steeds 3 opties worden gegeven. Dit is genoeg keuze om het te personaliseren, maar niet te veel waardoor je overweldigd wordt door de keuzevrijheid. Ik denk dat deze manier iedereen een goed gepersonaliseerd rif geeft. Ook de VR is heel handig, zodat je zeker weet dat het past in je tuin!
Dat je het op jouw voorkeurs plek kan plaatsen(mussen rif lijkt mij juist voor zwaluwen heel geschikt (die hebben nog maar weinig plekken in Nl en de vorm doet mij aan hun nest denken)
Goed voor de leefomgeving.
Stimuleert tuinleven
Goed dat er op basis van jouw tuin en ruimte een advies komt. Hier is het ook interessant te zien wat geadviseerd wordt wat betreft hang hoogte, of hoeveelheid. (Kunnen er 4 naast elkaar of moeten ze minstens 5m uit elkaar?)
Leuk dat je kunt kiezen qua soort, vorm en een kleur.
Zelf aanpassen op de soort tuin, bezonning, elementen in de tuin.
Bezig met biodiversiteit
er zal ongetwijfeld vraag zijn naar personalisatie, wat is echter het effect op de kosten en de kosten/baten ratio?
de mogelijkheid tot personaliseren
Ook hier meer natuur in de stad, en zal daardoor leefbaarder zijn.
Dat het overal toepasbaar zou kunnen zijn. Ik zou vooral geen kleur toepassingen aanbieden.
Ruimte tot aanpassing levert de mogelijkheid om het reeds af te stemmen op de beschikbare ruimte. Iets dat met een balkon zeker en item kan zijn.
Zie boven
Je kunt kiezen wat bij je past
Keuze en personalisatie. Het is mijn tuin dus het moet daar inderdaad in passen
Voor iedere situatie en wens aanpasbaar
Doordat er een beeld via VR gevormd kan worden van hoe het eruit gaat zien, is het makkelijker om een indruk te krijgen van of het wel of niet past.
De mogelijkheden om VR toe te passen, keuze voor kleur en grootte
De drie opties
Flexibiliteit
De keuzemogelijkheden + live visualisatie
Keuze, nadruk op biodiversiteit
Persoonlijk en aangepast aan de plek waar ik hem wil neerzetten. Vooral dat hij al aangeeft wat het beste op die plek zou passen.
Er zijn duidelijk nu opties erbij, maar het zegt me niks wat ik hiermee kan

Wat vind u niet zo goed aan het concept? Hoe zou u dit aanpassen?

25 antwoorden

“Ik zou eventueel de optie toevoegen om meerdere soorten rif in 1x te kunnen selecteren als dat past in jouw buitenruimte?
Eventueel ook nog een meerkeuzeoptie bij de maximum afmetingen van het rif. Misschien dat bepaalde afmetingen populair zijn of handig om te gebruiken, dan hoef je daar als consument niet over na te denken. (wel als optioneel misschien, zodat je ook alsnog eigen afmetingen kan geven als je wel afmetingen weet die je wil)”
De regenpijp rif zou ik lange ‘armen’ of leidingkjes met gaatjes geven zodat het water over een grotere oppervlakte verdeeld kan worden.
Regen rif is voor mij niet duidelijk(Foto herken ik niet)
Geen opmerkingen
Focus op eigen wensen zou ik niet zozeer doen. Ecologisch advies toelaten aan de experts van het bedrijf zou top zijn.
“Kijken of óók plaatsing haalbaar is op een balkon aan de railing of muur.
“

Zou leuk zijn als het modulair is. Misschien duur om te maken als alles gepersonaliseerd is?
Ik zou de dingen op een natuurlijkere manier aanpakken maar daar zit geen verdienmodel op.
ik zou er wel voor willen pleiten dat dit niet allemaal louter digitaal gaat plaats vinden, maar dat er ook gewoon menselijk contact mogelijk blijft (desnoods via een soort community?)
-
Men is natuur niet zo gewend, trekt namelijk ook insecten aan en vogels laten ook hun behoefte vallen wat meer werk geeft. Tuinen van tegenwoordig worden in de stad volgelegd met tegels, omdat men minder werk wil.
Voor veel mensen zal het te complex zijn om uit te voeren. Ben bang dat het snel te veel wordt voor een hoop mensen.
/
Geen idee
Helemaal niets slecht
Ik wil zien hoeveel moeite het kost, hoe duur het is en wat de benefits per systeem zijn.
Misschien wat ingewikkeld om te snappen
Weet ik niet
Niks
Niet van toepassing
Misschien teveel keuze, toch meer standaard.
Nvt. Mogelijk zal de prijs aan de hoge kant zijn (?), maar dat is een keuze natuurlijk. Misschien de mogelijkheid om als buurt een X aantal verschillende reefs aan te schaffen voor een pakketprijs, om zo door de buurt heen biodiversiteit te stimuleren? + onderling leren van elkaar wat betreft plaatsing, onderhoud, etc.
Voor een balkon lijkt alleen de regenrif logisch
Ben meer benieuwd hoe vrij ik zou zijn in het aanpassen van de vorm. Is het zoals een Zbrush/virtueel kleien of meer met sliders die je kan aanpassen? Virtueel kleien zou mijn voorkeur hebben
Vaag en onduidelijk concept. Als ik de autheur geen goed hart aan zou dragen dan zou ik het niet eens verder lezen dan de eerste zin.

Concept C

Wat vind u van het concept?

25 antwoorden

Leuk!
Leuk idee, maar ik hou van vogels en de natuur helpen, maar zie het nut niet van dit pakket en denk dat je er echt iets mee moet kunnen wat aan jou en de natuur bij draagt of aan de vogels om het toe te passen. Dus duidelijker het voordeel daarvan voor de gebruiker en de dieren etc
Goed idee.
Mooi/goed
Dit lijkt me logisch voor als het bijdraagt aan onderzoek van Natuurmonumenten of iets dergelijks. Dus een onderzoeksrapport na een verloop van tijd is top.
Voor de echte liefhebber.
Leuk ,maar wel voor een beperkte doelgroep denk ik.
Ja als experiment zou het bij een bepaalde groep aan kunnen slaan en creeer je saamhorigheid en bewustzijn.
Dit vind ik uiteraard het beste concept tot nu toe, want ik heb net bij mijn vorige antwoord iets soortgelijks voorgesteld (zij het zonder wetenschappelijke pretenties)
heel leuk
Nogmaal goed idee
Ook hier ben ik bang dat weinig mensen er aan deel willen nemen. Elke paar maanden iemand op bezoek van Urban Reef lijkt mij onnodig. Dit gaat echt over een specifieke groep mensen die hier aan mee willen doen.
Dat je aan kan sluiten bij een groter geheel, kan zien hoe anderen het doen, en deel uit kan maken van hobbyisten / een community.
Te bewerkelijk, te veel “gedoe”
Teveel werk
Meten is weten! Top
Een beetje intensief
Vind ik veel te technologisch
Zeer gaaf voor kinderen. Zo betrek je ze in de natuur en de wetenschap
Als je wilt draag je persoonlijk bij aan onderzoek.
Lijkt wel wetenschap! Te groot voor een individu
Goed, hier is denk ik wel animo voor, maar voor een selecte (geprivilegeerde..) groep.
Persoonlijk geen behoefte om bij een community te zitten, lijkt me erg veel moeite
Dit klinkt als veel moeite maar het bijdragen aan wetenschap lijkt mij leuk
zie eerder antwoord

Wat vind u goed aan het concept?

25 antwoorden

Dat burgers op een laagdrempelige manier worden aangespoord om zich bezig te houden met de wetenschap achter het rif. Ook de sociale interactie via de app en de betrokkenheid vanuit Urban Reef geeft de gebruikers de gelegenheid om met mensen te sparren over een onderwerp die je beiden interessant vind. Daarnaast ook de natuur vieren zoals al is genoemd.
Een communie of gebruikers gemeenschap maken is prima. Zelf denk ik als je complete schuttingen maakt of balkon afscheidingen met dit er in en ruimte voor planten op diverse hoogtes en een zaden pakket en aarde erbij dat je hoger zal scoren. En dan vooral focus op voedsel en kruiden op balkon en stads tuin
Gemeenschap erbij betrekken en resultaten zien.
Het stimuleert met de natuur bezig te zijn
Data kan interessant zijn om inzicht te krijgen in biodiversiteit, maar vraag me wel af waarom/waarvoor je data wilt.
De extra informatie voor geïnteresseerden.
Gaat heel erg de diepte in. zou leuk zijn voor (jeugd) natuurclubs, dus meer op openbare of gemeenschappelijke plekken
Bewustzijn creeren en het monitoren.
dat het niet tot een tuintje beperkt blijft, maar dat het onderdeel wordt van een gemeenschap(je)
de connectie tussen wetenschap en burgers, en het samenbrengen van verschillende reef bezitters
Stad wordt betrokken bij de natuur, en kan daar zelf aan bijdragen
Niet goed genoeg om er mee te willen werken.
Delen van informatie om van te leren; crowdsourcing research
Fijn voor mensen die dit wel willen bijhouden en de app willen downloaden
Goed dat je verschillende riffen kunt kiezen
Meten is weten
Dat het je in de gelegenheid stelt mee te doen aan onderzoek (dat uiteindelijk leidt tot...).
Het zal ongetwijfeld mensen aanspreken die het fijn vinden een community te vormen
Zie bovenstaande
Keuzemogelijkheden. Communitydenken
Draagt echt bij aan de natuur / omgeving
Combineren van biodiversiteitsherstel met onderzoek.
Overzichtelijk
De bijdrage aan wetenschap
zie eerder antwoord

Wat vind u niet zo goed aan het concept? Hoe zou u dit aanpassen?

25 antwoorden

“Het kan voor sommige mensen misschien als veel klinken om elke 2 weken een update te geven via de app met foto’s en metingen. Misschien dat dit sommige consumenten ervan weerhoudt om dit pakket te kopen.
Aan de andere kant kan die consistentie juist ervoor zorgen dat je bezig blijft met de natuur en je rif, wat ook een soort mindful activity is, gecombineerd met de wetenschap delen. “
Dat het nu wetenschappelijke is en wat heb ik daar in de praktijk aan, dat is me niet duidelijk
Weet ik nog niet.
Geen idee
Als gebruiker hoef ik geen wetenschapper te zijn. Data wil ik delen met echte wetenschappers, niet met andere gebruikers.
Ik vind het ontwerp genoeg om voor te zorgen, hoef geen nadere instructies.
Het technische deel met uploaden enzo is vaak heel tijdsintensief en niet makkelijk te installeren/toegang toe te krijgen. Ik denk dat veel mensen afhaken als ze zoiets in hun eentje moeten doen.
Ik heb geen idee het is niet echt mijn ding.
ik zou oppassen met het te ingewikkeld te maken, voor je het weet heb je alleen een groep nerds over; wellicht moet je uitgaan van een kern van actievelingen en een grote cirkel van passievelingen, maar wel geïnteresseerden, erom heen
“Ik heb recentelijk een college bijgewoond van iemand die citizen science rondom water deed. Daaruit bleek dat verschillende mensen verschillende levels van interactie waardeerden. De optie om meer automatische sensoren te hebben als meer analoge sensoren kan dus meer mensen actief krijgen.

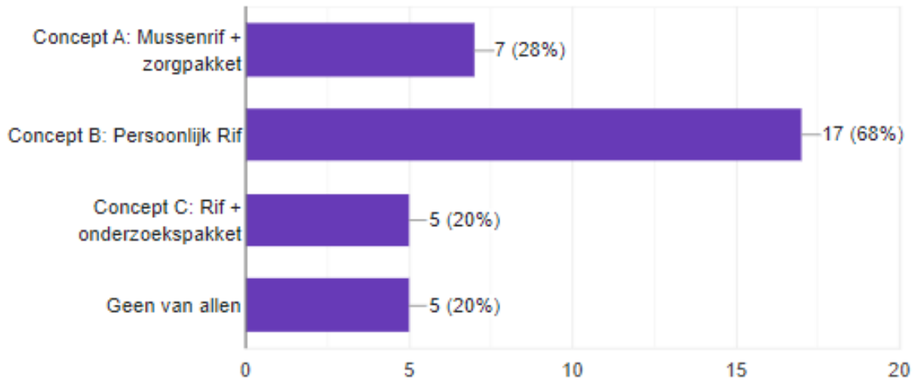
Ook zou ik graag de statistieken zien die verzameld worden.”
--
Te ingewikkeld, te veel werk, voor veel mensen waarschijnlijk niet interessant.
/
Te veel gedoe
Teveel opdrachten die moeten.
Ik zou zelf er niet aan meedoen tenzij het automatisch data verzamelt en verzend en mij 1x in de zoveel tijd eventueel iets zinnigs kan zeggen. Meer voor hobbyisten
Het vergt toewijding, maar degene die hiervoor kiest, zal dat geen probleem vinden.
De technische snufjes die worden toegevoegd vind ik in tegenspraak met het idee een natuurlijk proces te bevorderen
Wellicht een tekst specifiek voor kinderen schrijven
Geen idee
Ingewikkeld. Aanbieden aan communities of woongemeenschap
Voor wie doen de citizen scientists onderzoek? Gaat Urban Reefs iets met de data doen? Het doel van het onderzoek/metingen doen is mij nog niet duidelijk.
Verplicht monitoren, bezoek ontvangen of berichten krijgen van een app zou mij afschrikken
Dat het urban reef al automatisch de data verstuurd zonder dat ik daar heel veel voor moet doen. Met NFC de data ophalen en meteen kunnen verzenden. Het foto maken snap ik dat ik dat zelf dan moet doen. Een evenement zou ik ook niet echt nodig vinden.
zie eerder antwoord

Concepten naast elkaar

Als geld niet zou uitmaken welk rif (en bijbehorende pakketten) zou u dan willen kopen? (kan meerdere selecteren)

Kopiëren

25 antwoorden



Kunt u uw antwoord uitleggen?

25 antwoorden

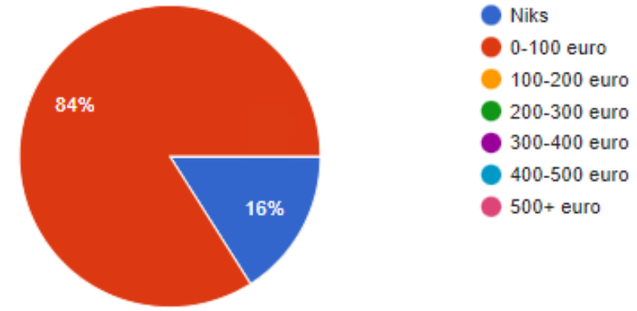
Ik vind het dagboek van het mussenrif heel fijn en dat het verzorgingspakket wordt aangeleverd. Ik vind het bij Concept B fijn en leuk dat je zelf kan kiezen uit verschillende soorten rif die past in jouw buitenruimte. Een combinatie van concept A en concept B zou ik het leukst vinden.
Water opvang en dieren helpen incl insecten is prima daar help ik graag aan mee
Wil bijdragen aan biodiversiteit .
Ik wil niet gedwongen worden om allerlei dingen bij te houden
Bij a en c heb ik meer vragen. b lijkt me te ontzorgen in dat ik niet goed weet wat bij mijn balkon past en geschikt is voor de juiste biodiversiteit.
Ziet er leuk uit en óók nog persoonlijk te maken + lijkt ervoor zorgen goed haalbaar
Ik vind alleen vogels niet zo interessant. Ik vind juist dingen met water, vijver, algen, planten interessant
Niet mijn ding ik zou bijvoorbeeld rommelige hoekjes in mijn tuin maken en me richten op een natuurlijke vijver met natuurlijke elementen er in.
Ik sta ernstig in dubio, ik ben meestal van het actief betrokken willen worden bij iets (vandaar C), maar ben eigenlijk op dit specifieke terrein altijd hoogstens een meeloper geweest van mijn echtgenote
het personaliseren en onderdeel zijn van een community trekt me erg aan. Ook vind ik het leuk om bij te dragen aan het ontwikkelen van de urban reefs
Ik woon op het platteland en heb talloze mussen, zwaluwen, vleermuizen
Naar mijn mening is dit concept voor de echte vogel en insecten liefhebbers. Mijn tuin verzorg ik met voldoende planten voor insecten en bollen en potjes voor de vogels, incl een waterbak.
Ik steun graag onderzoeken
Simpel en duidelijk

Vrijheid om je eigen rif in te richten
Hoe kan ik bij 1 van de concepten kiezen voor Kopen als de concepten vooral verschillen in selectie manier en uitleg?
Ik denk dat concept B beter is aan te passen bij onze omstandigheden, mogelijkheden en wensen.
Vind ik het vriendelijkst en het meest direct
Ik word heel blij van de concepten en wil ze allemaal wel in de tuin hebben!
Teveel te doen om ook aan het onderzoek mee te doen.
Hoef niet zo nodig met anderen dit te doen of te delen. Mussen genoeg in de tuin, dus die hoeven niet aangemoedigd te worden.
Geeft de meeste keuzevrijheid. Optie C vind ik ook erg leuk, maar het doel van het onderzoek/toegevoegde waarde van de moeite die ik in de metingen doorgeven zou steken, is mij niet duidelijk genoeg.
Het minste werk na implementatie
Dit lijkt mij het leukste om te doen en dit past ook beter bij mijn balkon dan het mussen rif. En niet zoveel moeite als het wetenschap project.
Vaag en onduidelijk

Hoeveel geld zou u willen betalen voor het Mussen Rif van Concept A?

Kopiëren

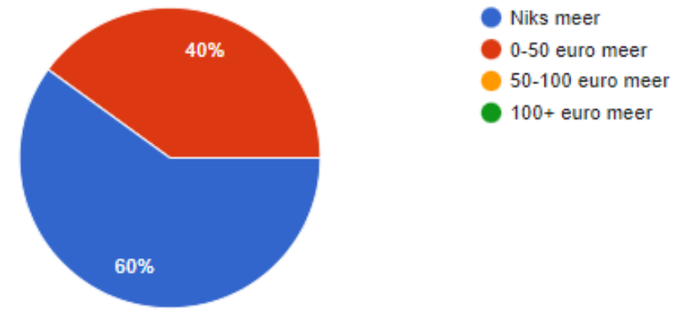
25 antwoorden



Als u het Mussen Rif kan aanpassen naar jouw voorkeuren (zoals bij Concept B), hoeveel geld extra zou u er dan extra voor betalen (vergeleken met het antwoord van de vraag hiervoor)?

Kopiëren

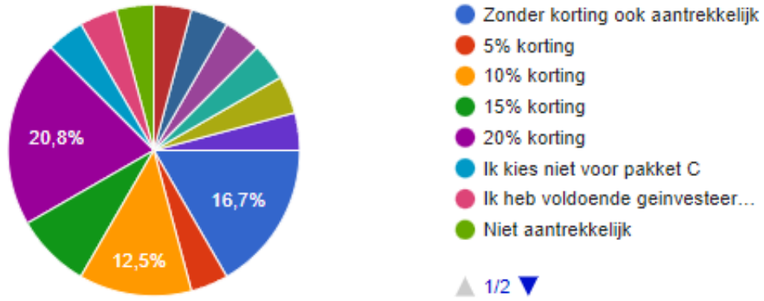
25 antwoorden



Zoals genoemd bij Concept C kunt u met het aanschaffen van het onderzoekspakket een korting krijgen op het Mussen Rif, hoeveel korting (op het bedrag ingevuld twee vragen hiervoor) zou dit pakket voor u aantrekkelijk maken?

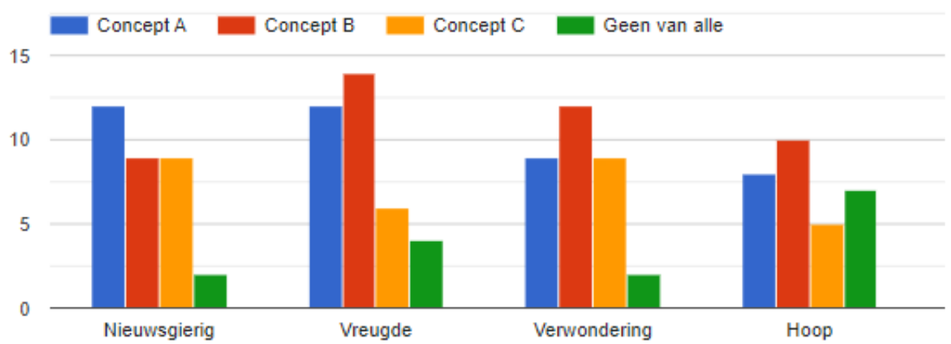
Kopiëren

24 antwoorden



Kunt u aanvinken welk van de concepten u de volgende emoties laat voelen? (kan meerdere selecteren)

Kopiëren



Heeft u nog andere op- of aanmerkingen?

14 antwoorden

nee, superleuke concepten !
Ja maak er een ophang paneel van waar planten in kunnen met automatische irrigatie en via de regenpijp voor op balkons en automatische irrigatie erbij maakt het zoveel makkelijker als het om een overdekt balkon gaat waar geen regen komt
Nieuwsgierig naar eindresultaat.
Nee

Ik vind het een héél mooi initiatief

Ik hoop dat jullie een leuke doelgroep gaan vinden met mensen die enthausiast worden van het monitoren van wat er in de rifs gebeurd.
Als je het een beetje goed wil doen (dus spontaan antwoorden combineren met nadenken), doe je dit echt niet in 10 minuutjes (maar door ervaring wijs geworden had ik daar al niet op gerekend, kostte nu ruim een half uur); als dit ook een verdienmodel moet worden (wat ik bijna per definitie een slecht idee vind), dan zijn de vragen over wat het mag kosten teveel zonder context, hoe dan ook, veel succes met dit project en de groetjes

Geen, veel succes met je onderzoek!
helaas is dit niet aan mij besteed omdat ik al voldoende doe aan de bio diversiteit in mijn tuin.

Leuk idee

Succes!

Ik hoop dat dit gaat werken en straks ook echt verkrijgbaar is
Dit laatste onderzoek heb ik geen idee. Heb het nodig om het in het echt te zien.

Ik voel me niet meegenomen in dit concept. de vraag “Woon jij in de stad en heb jij een buitenruimte (tuin/balkon/dakterras)?” werd gesteld. Verder weet ik niet wat ik hiervan moet verwachten. Opeens gaat het over mussen en water. Wat kan dit voor mij doen, of voor mijn omgeving. Is het hetzelfde als vleesmuishuizen? Maar daar hoef ik geen dagboek voor bij te houden. Dit klinkt als gedoe.

Appendix L - Guidelines for citizen science to increase nature connectedness

Based on the outcomes of the interviews and group session, together with research

Choose one or two pathways to nature connectedness to focus on.
Senses: Usually when it involves observing nature or other kind of interaction with the senses (touching, smelling, listening etc)
Emotion: When the object/research helps create a space where nature can be enjoyed
Compassion: If people are able to physically care for the living object or other nature.
Cultural meaning: If it connects people with each other and can create awareness about nature.
Beauty: If the object/nature on it has an unique shape with many different aspects.
It is common/logical that the citizen science experiment will focus on senses and compassion/cultural meaning.

It is not the goal that the participants gain knowledge but rather that they start to pay attention more to nature and develop a curiosity to learn more about nature through experiences/experimenting.
The experience can be the citizen science experiment as well as questions that are asked around it.

Organize co-creative sessions before, during and after the research to actively involve participants in the experiment and awaken their creative mind.
Leave a lot of space for participants to personalize/ create their own experiment.
Let participants share experiences/thoughts/ideas throughout the process.

Have at least one personal interview during the process to find out more in depth about the participant and receive a (relatively) unbiased/uninfluenced opinion.

Make it a mindful and smooth experience where people are focused on regularly paying attention on the living artefact only
Use paper and no phone/laptop.
Ask people to really pay close attention and to describe what they see / feel.

Add a fun and personal element to it that integrates into their (social) life and home
Like giving the artefacts a (nick)name
sharing progress with loved ones or other participants
Let people think what the living artefact would want and be creative in ways of taking care of it.

Think of how the experiment can possibly inspire behaviour change and which ones.
Make sure there is a positive behaviour change, for example: of noticing nature, being aware of the nature around us in the city, taking more care of nature, recognising the signs of nature, interacting more with nature etc....

Have a regular interval of short measurements for a long period of time so that the paying attention to the object/nature becomes part of their life/rituals.
Have an experiment that is at least 30/60 days so that it can inspire the habit of paying attention to nature.
Daily activity would be best to create a habit. However weekly could perhaps also work.
The measurements should be as short and smooth as possible, 5 to max 10 minutes.