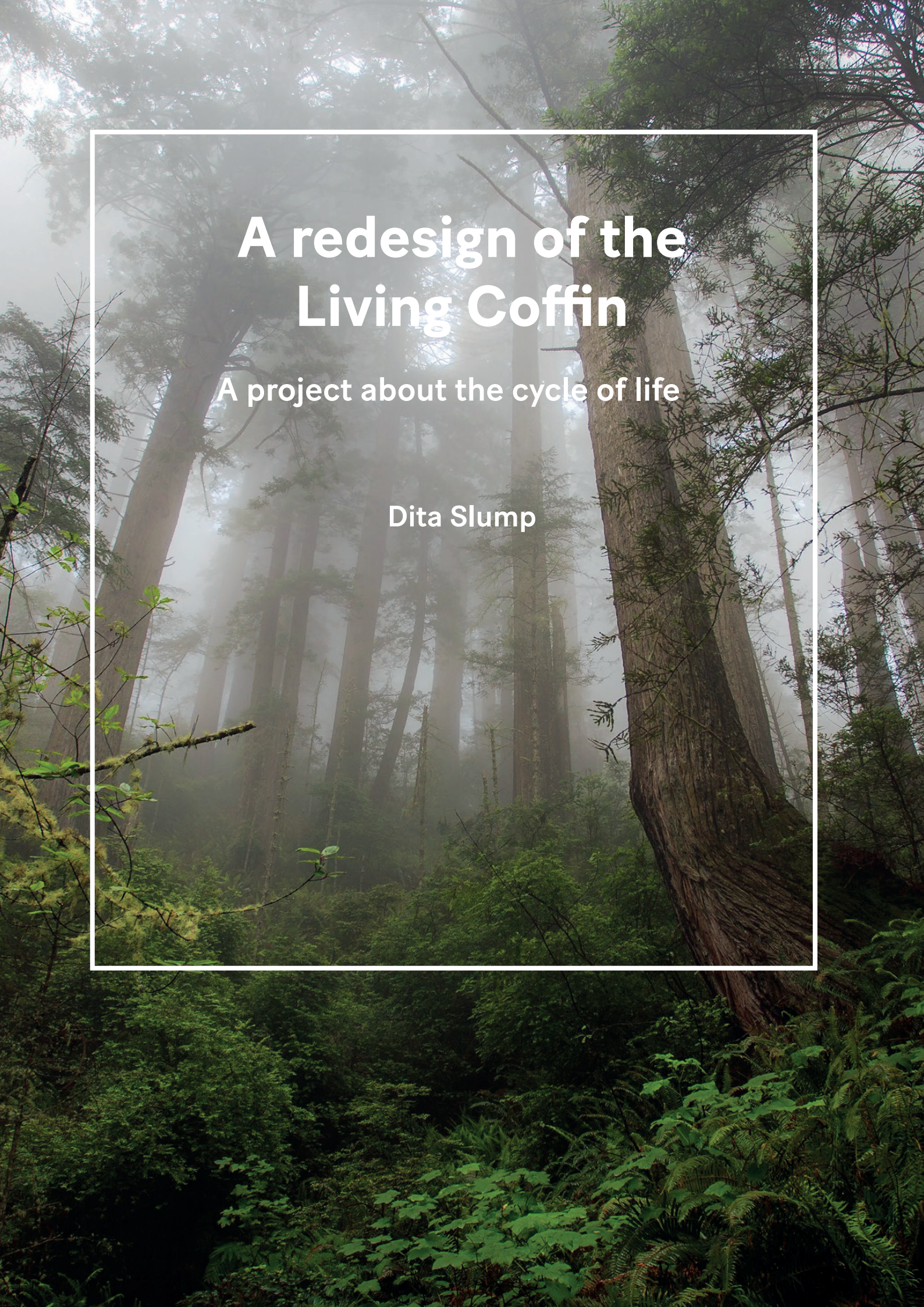

A redesign of the Living Coffin

A project about the cycle of life

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Master Thesis | Integrated Product Design
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Figure 1. Current Loop coffin

Acknowledgements

Throughout the writing and execution of this graduation project, I have received a great deal of support and assistance.

I would first like to thank my supervisor, Professor Marieke Sonneveld, whose expertise was valuable on so many levels. Your insightful feedback, allowing my participation in the end-of-life lab and design approach pushed me to sharpen my thinking and brought my work to a higher level.

I would secondly like to thank my mentor, Dicky Brand, who supported me create and reflect on all ideas. Providing me with new insights and inspiration during the coaching sessions helped me develop a result I am very proud of.

I would like to acknowledge my colleagues from my internship at Loop-Biotech for their excellent collaboration. I would particularly like to single out my supervisor at Loop, Bob Hendrikx. Bob, I want to thank you for your patient support and all of the opportunities I was given to further my research. Using a great amount of mycelium to work out all impulsive ideas, being enthusiastic, and looking from a realistic perspective throughout my studies.

In addition, I would like to thank my parents and family, for their wise counsel and sympathetic ear. Finally, I could not have completed this project without the support of my friends and boyfriend, who provided stimulating discussions as well as happy distractions to rest my mind outside of my research.

Figure 2. Fungal bouquet

Glossary

User group: The user group refers to all the stakeholders. This contains the 'providers' and the 'end-users'. Family, coffin designers and undertakers, basically all groups who are involved with the coffin.

Providers: When looking at the stakeholders involved in the funeral industry, the 'providers' is the group who offer a product of service. Concerning the providers, the meaning of a funeral is clear: it is the product/service they sell, with the means to make money.

End-user group: When looking at the stakeholders involved in the funeral industry the end-user is the group that pays for/ benefits the product and services offered by the providers. Three types of end-users are distinguished: close bereaved, visitors and the deceased.

Close bereaved: The inner circle, like the family and friends closest to the deceased and most involved in the funeral process.

Deceased: The person who passed away.

The body: Is the body of the deceased. The personality of the deceased is of less importance when talking about the body.

The current living coffin/ the current Loop Cocoon: The design of the coffin that is currently on the market.

The redesign /vessel/ Loop Cocoon: The design that will be created during this graduation project.

Vessel: A vessel (in dutch voertuig) can be used in many contexts, it can refer to a ship, container, tube or anything that is a casing and transports.

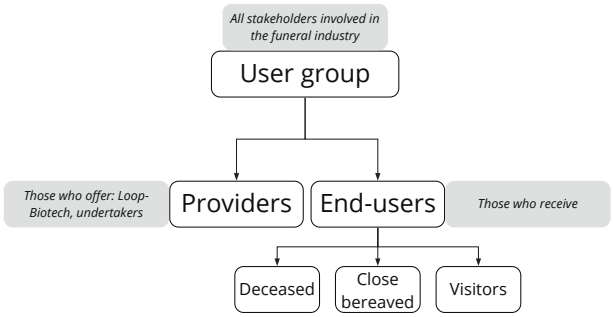


Figure 3. Stakeholders

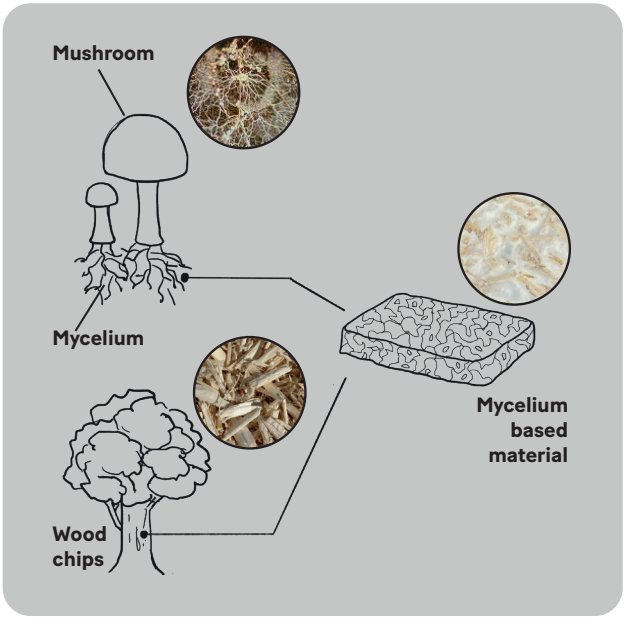


Figure 4. Mycelium based materials

MDD: The material driven design method.

Mycelium: Mycelium is the network of interwoven colonised thread-like hyphae that constitutes the vegetative part of mushrooms. A 'hypha' is the most basic developmental unit of filamentous fungi, which grows by extending and branching their hyphae into a substance.

Mycelium-based materials: This colonisation of roots makes a biodegradable living material used in product design, architecture, fashion and more. These materials were introduced almost ten years ago by Ecovative (Ecovative, 2016). The material is a living organism and goes into hibernation when all moisture is withdrawn. But after it contacts moist again, like wet soil, the material will continue growing.

Experiential: The experiences that people have with and through the product.

Externalising: This is showing or expressing something on the outside of a product.

The effect level means two things:

- what you want the user to do, experience, feel, and how you want your user to behave during the funeral process.
- And secondly, what effect is relevant to the user's ritual.

Preface

Preface

This graduation project is initiated by personal experience during my bachelor and masters. The starting point was the search for a design topic that has personal meaning and interest.

Sustainable design
My interest in biodegradable materials started even before my design education. It has always been my vision to create products that would leave a minimum footprint on the planet. During bachelor and masters, it has always been a motivation to pursue a career in biodegradable product design.

Emotional value
Besides sustainable design, I missed the deeper meaning of design. How can my product help someone and support in times of need on an emotional level? With the master Integrated Product Design, design is mainly driven from a practical point of view. My ambition is to research and involve emotional value in my graduation project.

Living coffin
In researching biodegradable materials, I came across the living-coffin from Loop-Biotech. The mycelium uses the whole body as nutrition for the environment and enriches instead of pollutes. It would demolish even metal and plastic parts such as metal hips or fillings in the teeth.

I then contacted Bob Hendrikx, owner of the startup Loop, to discuss his company and a potential graduation assignment. The desire was there to change the aesthetics, communicate the livingness of the material and the cycle of life more clearly through the design. A perfect assignment that would cover both my interests: sustainable design and emotional value.

Project ambitions
Professional
During my bachelor and masters, the end goal of all projects is mostly concept based. The assignments mainly were fiction and the final design as advice for a client. Learning to put an idea into an actual product, ready to be produced and put on the market, is a unique achievement that has not been done in my career so far.

Personal
The list below shows my learning ambitions.
- My ambition is to learn to design with a biobased material. By using the Material Driven Design Method, a deeper understanding of the material mycelium is formed. This method provides insight and opportunities in the performance of mycelium.
- Going beyond the concept design and turning the concept into a tangible product. With a hands-on approach and the embodiment of the final concept, this is realized.
- Learn to incorporate people's emotions and rituals into the design through thinking in narratives and experiences. During the master IPD these factors are taken less into account when designing. Being empathetic and providing emotional support with a design gives an extra dimension to the project.

So, for the last 20 weeks, this topic had my full intention and I enjoyed it to the fullest. It has been a challenge working with a material so little is known about. This project covers the end-of-life, and everything that comes with it. All different topics are looked into from the grieving process, the cycle of mother nature, the living material and the funeral industry.

I hope you enjoy reading this report as much as me making it!

Figure 5. *Current Loop coffin detail*

Summary

Executive summary

This graduation project is done with the Industrial Design Engineering faculty for the Master's programme Integrated Product Design (IPD) and cooperating with the End Of Life Lab.

Loop-Biotech is a Dutch start-up based at YES Delft and sells the product the 'Living coffin'. A coffin made out of the living material mycelium. Loop's purpose is to enrich nature and has the ambition to restore the human-nature relationship. Its objective is to grow its business and become a trend worldwide. The scope for this project concerns Natural burial in the Netherlands.

1. Introduction
The reasons for the research are to ensure consumers' wellbeing and meet their needs. The current design can cause stress and insecurities with the end-user and providers due to product failure and design mistakes. Internal communication with Loop showed a desire to improve the shape, experience and production process.

The assignment of the project is to redesign the mycelium coffin to reflect and communicate the contribution to the cycle-of-life through aesthetics and create an experience to support the funeral ritual.

The research will be used as input to realise this goal. As guidance for the development of mycelium or fungi-based products and growing in the funeral industry, the main research question is as follows:

How can a mycelium funeral vessel be designed on a technical and experiential level to support and optimise its meaningful value in the funeral industry?

Figure 6. Current Loop coffin

2. Research
The research investigates five topics; These five topics mainly focus on providing insights about the current coffin, opportunities for the funeral ritual in the industry, the material and a contribution to the cycle-of-life.

(1) The company: Research about the production, company and current coffin. The 'coffin' product perception causes failure and insecurities during usage.

(2) The material mycelium: Testing the material's performance with the MDD method shows it is possible to see and feel the material, which emphasises the material's naturalness and 'living' characteristics. Additionally, the basic instinct of the material (to demolish) is suppressed, and products are shaped in basic shapes and forms.

(3) The market: The funeral industry is changing and teaches us that it will move in four directions. Personalisation of mortuary rituals, increasing environmental awareness, high-quality services and death becoming a more accessible topic to talk about.

(4) The end-users, researched through interviews and desktop research, are expected to follow the trends the funeral industry provides. They feel the need to mourn the death of someone, come together, perform a ritual and create a meditative experience that intends to help with emotional healing and thereby creating a memorable moment through a greener burial ritual.

(5) The providers are researched through interviews and desktop research. Providers want to present consumers with product and service options that are sustainable and biodegradable. The natural burial trend meets the needs and offers opportunities. Since they do not want to overkill the consumer, simplicity and back-to-nature will become more popular styles to offer.

3. Design direction
With the improvement of design elements, this project will showcase an experience supporting and enriching the funeral process experience using aesthetics and rituals.

"Design a funeral vessel that includes an optimised mould system for sustainable production and product-use, while creating a memorable moment when life comes to an end".

The challenge is to create a different product perception.
The ambition for the redesign is to distance the consumer's perception from a coffin and stimulate perception as a vessel or Cocoon for the body.

4. Ideation
The diverging phase, described in this chapter, shows the search for a design that fits the design direction. It investigates possibilities that are used later on during the concept design phase. Methods such as collage-making, brainstorming, sketching, and a speedform study are selected, and the required physics are investigated. All the requirements and wishes eliminate ideas that do not meet these demands. The ideation resulted in three concepts.

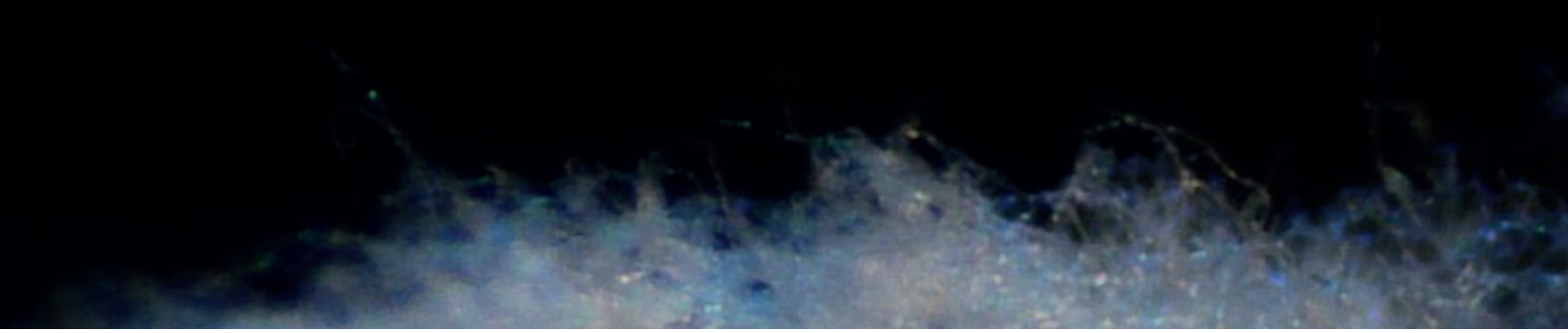
5. Conceptualisation
For the concept design phase, three concept designs are developed equally. The design process of the three concepts is visualised. Different elements (the shape, the interaction and the production) are worked out apart.

6. Final Design
The research, ideation and conceptualisation resulted in the redesign of The Loop Cocoon. To allow the transformation from death into new life, restore a connection with nature and create a memorable moment when life comes to an end.

7. Recommendations and discussion
The recommendations concerning the aesthetics, samples, functional development, sustainability, the assembly process and costs are discussed. They can be used as future steps to develop the Cocoon into a fully functional product. The discussion provided a project evaluation and personal reflection.

Figure 7. Final design

1. Introduction



1. Introduction

This project is positioned in the field of the funeral industry, an industry that has changed over the years. It is specifically focused on the natural burial in the Netherlands, one of the operating regions of Loop. To help paint the research setting, and before diving into the research itself, this chapter introduces the project partners, the company, provides the research context, elaborates on the reasons for research, and highlights the research goals and project approach.

1.1 Project partners

Loop-Biotech
Loop-Biotech sells the product the 'Living coffin'. A coffin made out of the living material mycelium. Since the company is a start-up in the beginning phase, the dynamic changes constantly.
For the last twenty weeks, they managed to start production in a factory,sale products, and win the Philips innovation award while helping with a great deal of this graduation project.

TU Delft
The Delft University of Technology (TU Delft) is a university in the Netherlands. This graduation project is done with the Industrial Design Engineering faculty, specifically for the Master's programme Integrated Product Design (IPD), and cooperating with the End Of Life Lab. The Design for End Of Life Lab explores how design can contribute to palliative care and the quality of life in its last stage.

1.2 Company introduction

Loop-biotech, a Dutch start-up producing the living coffin, was founded in 2020 in Delft (Loop-Biotech). Its purpose is to *"Enrich nature using living material instead of polluting our environment with dead materials* (Loop-Biotech)" and to *"create biodiversity, feed the earth and sprout new life* (Loop-Biotech)". They designed and launched a living coffin made out of the material mycelium, the root network of mushrooms. The coffin provides a sustainable burial option because of the energy-efficient production, breaking down body toxins once buried, enriching nature after burial and closing the cycle of life.

Loops' ambition is to restore. The restoration that Loop focuses on and acts upon is *"Our human-nature relationship"*, which they explain as *"We are here to restore nature. We do this by bringing human nutrients back into the cycle of life in the most natural way: with a living mycelium-based coffin"* (Loop-Biotech). The mycelium not only decays the body but feeds the soil at the same time to create biodiversity in the plants and trees that will grow.

Currently, the company managed to sell over 60 coffins but strives to grow. One of the objectives for Loop is to grow its business and create *"A worldwide innovative burial trend and culture"*, which means they want to become a unique and obvious choice to consumers and distinguish them from other average burial options available in the funeral industry.

The purpose to enrich and ambition for restoration is closely tied to the objective of growing its business. It provides the opportunity to create an impact at the end of one's life: *"How do you want to be remembered?"* (Loop-Biotech). This statement was created to encourage consumers to spread the message concerning environmental awareness and restore the human-nature relationship during and after the funeral process.

Besides spreading the statement another part of Loops' growth strategy is improving their product and gaining insights from the current coffin visitors and users. The result is a handful of remarks, product perceptions, questions regarding the design and use, and production bottlenecks. These observations and commentaries describe all stakeholders' (see figure 8 and 9) reactions to the coffin, from the end-users (funeral visitors, deceased and close bereaved) to the funeral providers (undertakers, carriers, producers, etc.).

Additionally, the changing funeral industry motivates Loop to adjust their product design. The currently moving market inspires Loop to act upon these changes and change the market itself. The bi-directional relationship is further explained in the research context (1.3).

This preliminary research was translated into insights to improve and innovate on design, experience and production. From this, development opportunities and strengths derive. It is by analysing and expanding these results that this research opportunity arose.

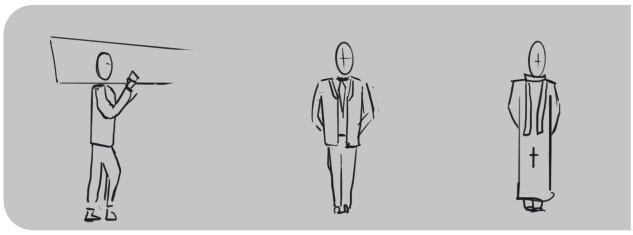


Figure 8. Providers

Figure 9. End-users

1.3 Research Context

This research focuses on delivering a product that improves the living coffin in the Dutch coffin industry. The scope of this research is in the Dutch natural burial market. It is researched how this has transformed and is transforming.

Funeral history
Around the 7th century, people buried their dead outside the settlements, in nature, with their ceremonies and rituals. Gradually, partly because of religion, the industry, being conservative and not progressive, preferred burial in or near the church. Due to old traditions, conventional norms, and ethical principles tied to end-of-life, innovation was not easy to introduce to the public.

However, zooming in on the Netherlands, comparatively speaking, the Netherlands is now one of the more secularised countries in the world. In secularisation and individualisation, traditional religious rituals have fallen increasingly out of favour (Bernts, Dekker, & de Hart, 2007), resulting in a 'quest for new rituals' (Wouters, 2002).

The industry reacted and changed when in 2019, the Funeral Service Act changed the law to allow new undertaking methods. Innovative ways of funeral arrangements had become known, which were officially prohibited. The innovative methods are the wishes of the next kin to be more sustainable in the funeral process. Requests were made by and received by providers like funeral directors and other funeral organisations such as coffin builders and designers to allow change to provide a personal and sustainable option.

These wishes force the industry to move to other more sustainable areas. (Venbrux, Heessels, & Bolt, 2008), facilitated by the consumer-oriented undertaking business. These innovations in the Netherlands provide an opportunity and will define the context of the project.

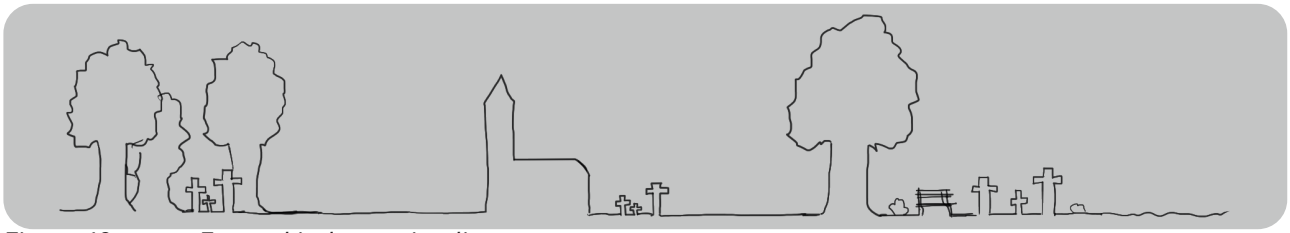


Figure 10. *Funeral industry timeline*

Natural burial
Burial, in particular, has been done for centuries. However, in the mid-nineteenth century, managing the rapidly expanding number of corpses had to be controlled and rationalised. This control could be exercised by business, the municipality, or the church, leading to three pure types of funeral organisation (commercial, municipal, religious). (Walter 2005). But nowadays this industry is changing, and these ways of organisation are mixed.

Natural burial is the most logical choice for the current living coffin. Cremating the mycelium casket will lose its purpose. Natural burial fits the idea of going back to nature, enriching the environment and a do-it-yourself funeral service. Which is why natural burial is researched in this project.

Conclusion
The funeral industry is transforming. Dutch stakeholders force the industry to move to other areas. As a result, the funeral industry mixes old traditions with new ones providing design opportunities and innovations introduced to the market. Natural burial is an upcoming trend providing these alternatives to be executed. This research will be used as input for redesigning the coffin.

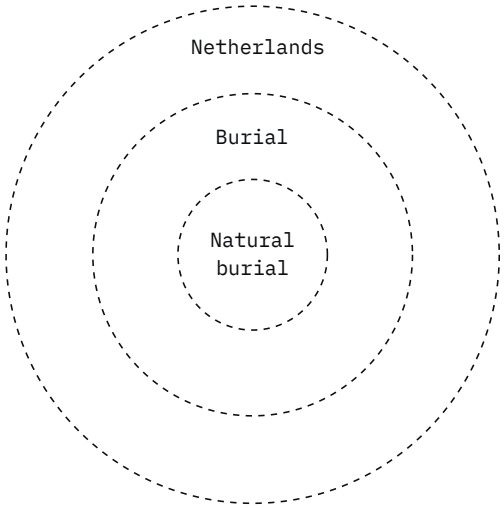


Figure 11. *Scope*

1.4 Reasons for research

Loop listened to the wishes to provide sustainable burial alternatives when creating the living coffin. However, after introducing it to the market, recognised the importance of innovating the design and its production, and highlighted a development opportunity to provide a new experience to their customer. Once this area of interest was established from the preliminary research through the product feedback and internal communication within Loop, it was clear that this also had to be in line with the current trends within the world.

Research has shown that funeral experiences help in the grieving process. They can be effective in helping people walk through the early days of grief after the death of a cared-for person, essentially helping family and community walk together as they carry their loved one "home" (Barnard 2019). More importantly, stress during this process causes a negative impact on the experience amongst the end-users. This indicates that the need for a positive experience and support in the funeral process is high during these times. The current coffin raises questions and doubts concerning the product performance, causing stress and unwanted worrying.

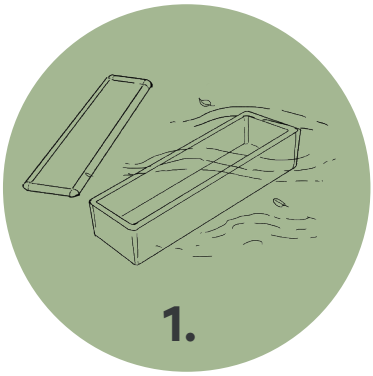
Furthermore, taking away these concerns is not only in the interest of the end customer. It is in the providers' interest to ensure the wellbeing of their customers, both for business purposes and for end-customers experience purposes.

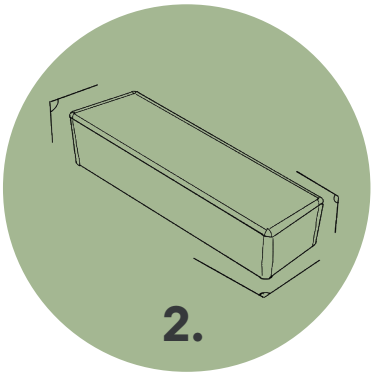
The major insecurities, derived from the product feedback, observations and internal communication, are:

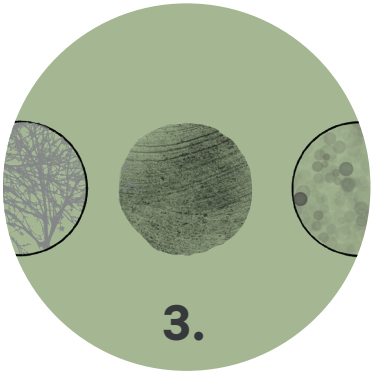
1. The current coffin is made from a practical perspective, reflecting in shape and aesthetics, trying to look like a standard coffin when it is not, causing doubts and insecurities about the product performance and how it should be used properly. For example, people are scared the lid will blow away, or the coffin will not hold the body weight.
2. The current coffin does not show the natural characteristics and its contribution to nature. The material can transform death into new life so that the body can become part of the cycle of life. The current coffin has good intentions, but this does not reflect in material and shape, and creates a deeper connection to communicate this.
3. As awareness of environmental problems increases, and in all industries, products and services are looking for ways to become more sustainable, so too does the funeral industry. The coffin is not perceived as such, being compared to unsustainable materials like styrofoam, concrete and a dead material.
4. The coffin is because of the material, a new product in the funeral industry. A novel material can be a functional innovation but does not warrant commercial success. Amongst the stakeholders, there is still doubt that the product will be adopted in society since some consumers do not like the idea of complete decomposition.
5. Moreover, scaling up the business and producing the coffin proved to have bottlenecks. The production is done via growing the sensitive living organism mycelium inside a mould. This production is expensive and complex. This complicates the business to grow and produce worldwide.

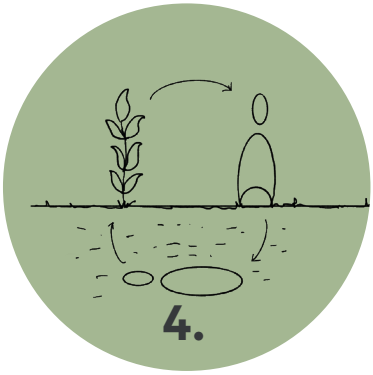
Conclusion

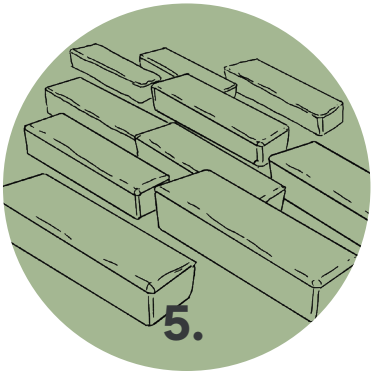
These findings regarding the funeral industry context indicate opportunities towards support during this funeral process to ensure consumers wellbeing. Next to the product feedback, concerning production, aesthetics, and overall experience, the transforming industry shows a clear reason for researching this topic and using it as input for the redesign.











1.5 Assignment

The goal of the research is to gain insights on what influences the feelings and needs of Loops' customers. Afterwards, the insights of this research are used as input to redesign the current living coffin.

This graduation project is about redesigning the *mycelium coffin* to reflect and communicate the *contribution to the cycle* of life through *aesthetics* and create an *experience* to support the *funeral ritual*.

"Redesign the mycelium coffin to reflect and communicate the contribution to the cycle of life through aesthetics and create an experience to support the funeral ritual."

Figure 12. Project assignment

The approach for the assignment is based on the reasons for the research. The goals are explained as:

1. Prevent insecurities about the product performance: The goal is to understand the stakeholders' needs, to prevent insecurities during the funeral ritual and to enrich the funeral experience.
2. Show its natural characteristics and contribution to nature: Research natural characteristics and transforming the deceased into the cycle of life. The cycle of life has several meanings. First, it means the life cycle of the product. Second, more spiritually, it means living on in the surroundings still being present elsewhere. Third, it implies the deceased's life is ending and continuing to live on in nature, and last, the memories created who will remain in others.
3. Not being compared to unsustainable materials: The Material driven design method will research mycelium opportunities to improve the material perception.
4. The coffin does not warrant commercial success: Research the funeral industry on how the product can be adopted by society.
5. Production has bottlenecks: Research alternatives for production and Loop growing its business.

1.6 Structure

The approach for this research is done through the Double Diamond Method.
The Double Diamond Method is the name of a design process model developed by the British Design Council in 2005. The official Double Diamond design model has four stages: Discovery, Definition, Development and Delivery. Together, these stages work as a map used to organise thoughts and to improve the creative process.
The structure of this graduation project is frequently used in design projects at the faculty of Industrial Design Engineering. With the double diamond method, the converging and diverging will lead to a final redesign.

For material development in the research phase, the Material Driven Design method is used. A method to understand the mycelium and characterise it both technically and experientially to articulate the material's unique role (in contrast to alternative materials) when applied in products and improve the current coffin design.

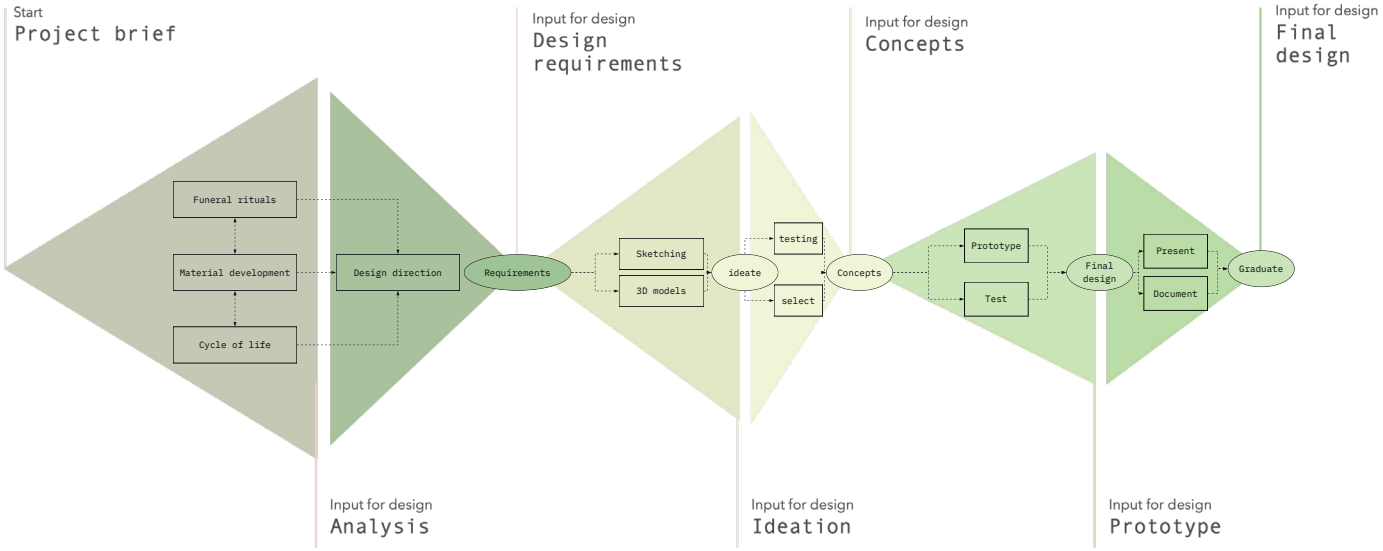


Figure 13. Double Diamond Method

Reading guide
Similar to the methodology and the structure of the research Double Diamond, the report is divided in seven sections. Figure 14 gives an overview of these sections which are visualised as columns and filled with the chapters. The arrows in the overview indicate the flow of information and show how the chapters relate to one another.

2. Research
The research investigates five topics; These five topics will mainly focus on providing insights about opportunities for the funeral ritual, the material and a contribution to the cycle of life.

(1) the company Loop-Biotech, researching feedback and improvements for the current coffin and their brand.
(2) the material mycelium, testing the materials performance with the MDD method
(3) the market, the funeral industry's history and where it is expected to go
(4) the providers, researching their needs through interviews and a desktop research
(5) the end-users, researching their needs through interviews and desktop research
The results of the research translate into a design direction.

3. Design direction
The insights of the research support the design direction. It narrows down the initial scope and provides boundaries to the project. With the help of a list of requirements and wishes, the project continues to generate ideas.

4. Ideation
This diverging phase of the project generates ideas that fit the design direction and meet most requirements. These ideas are analysed and tested to validate the potential. It ends with conversion and a concept selection.

5. Concept design
The concept phase of the project reflects on insights and ideas and combines them into three designs. Prototypes test the concepts. It results in a conceptual design of the product idea.

6. Embodiment
Lastly, the project expands the conceptual design into a final prototype. Through 'learning by doing' building moulds and growing a coffin, the desire is to have a final prototype ready to be fit for production.

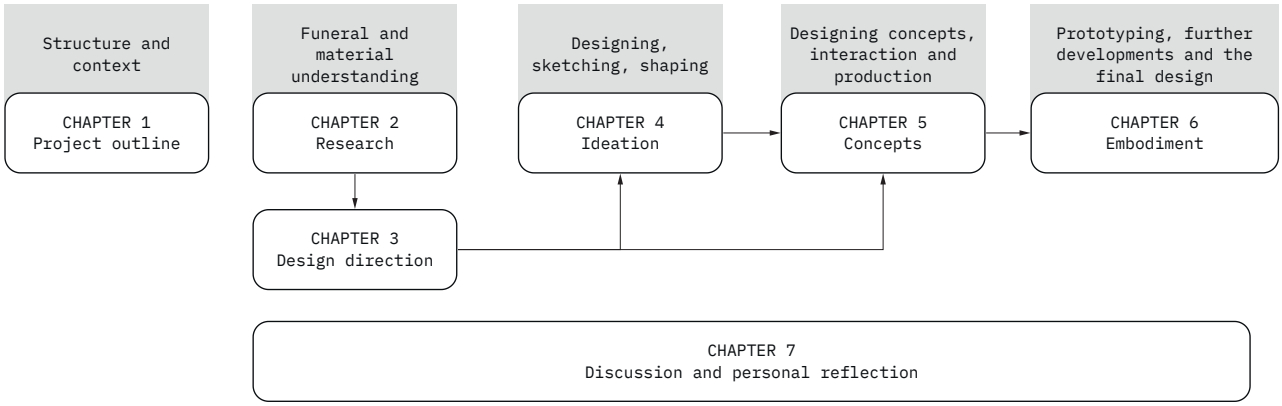


Figure 14. Reading guide

2. Research

2. Research

This chapter provides the analysis of five topics;
(1) The company, here the product details, company details, brand DNA and customer journey are discussed.
(2) The material, this covers the first two steps of the MDD and the work environment for working with mycelium.
(3) The market, or also referred to as the funeral industry history and future

The stakeholders and their funeral experience
(4) The providers, all the parties that sell or inform a product or service in the funeral industry.
(5) The end-user group, the group who pays for these products and services, like the close bereaved, visitors and the deceased.

1

Figure 15. Current Loop coffin

2

Figure 16. Mycelium

3

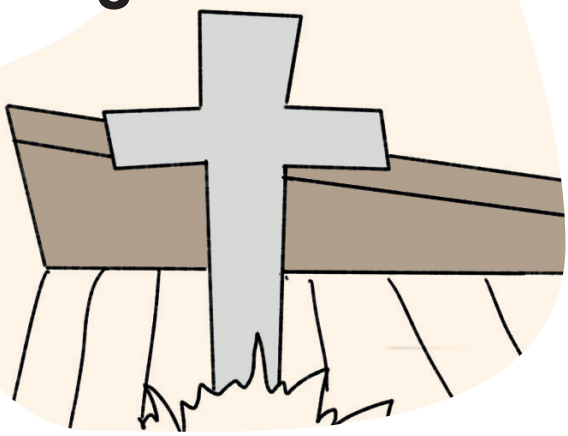


Figure 17. Funeral industry

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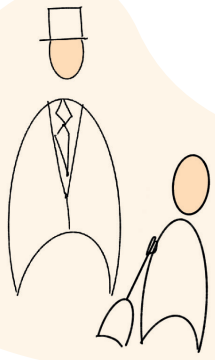


Figure 18. Providers

5

Figure 19. End-users

2.1 Research questions

The assignment of the project is to redesign the *mycelium coffin* to reflect and communicate the contribution to the *cycle of life* through *aesthetics* and create an *experience* to support the *funeral ritual*. The research will be used as input to realise this assignment. As guidance to understand what the needs of the users are, for the development of mycelium or fungi-based products and growing in the funeral industry, the main research question is as follows:

How can a mycelium funeral vessel be designed on a technical and experiential level to support and optimise its meaningful value in the funeral industry?

The redesign will be referred to as a 'vessel'. The current design is perceived as a coffin and placed into that category by consumers. The aim of this project is to distract it from this category. The reason for this is further explained in chapter 3.1. The project's objective is to provide consumers support in the funeral industry through a vessel.

Furthermore, interviews provide insight into the needs of the stakeholders, and material experiments provide insights into how mycelium's unique qualities can contribute to the design.

Figure 20. Current Loop Coffin

The main research question is divided into smaller parts. This gives five sets of questions: one for the feedback on Loop-biotech and the current coffin, one for the material and three about the funeral industry and its stakeholders. The research on material consists of several parts: mycelium based products, investigating theories and models and translating them into tools for the MDD method. In the MDD process, most questions are directed towards the first two phases of the MDD method as the third and fourth step are somewhat more general and relate to the ideation, concept and embodiment phase.

Company
1. How are Loop-Biotech and the current coffin reviewed?
2. How is the current coffin produced?
3. How does the current coffin perform?

Material
1. What are fungi based materials and products, and how are they developed?
2. What would the material's unique contribution be to a coffin?
3. What are the material's unique technical/ experiential qualities to be emphasised in the final design?

Market
1. How and why is the industry developing?
2. What are the wishes for the funeral process?
3. How can a Loop coffin be purchased?
4. What is already available in the current market?

The stakeholders
1. What is the role of the providers?
2. How will their role change over time?
3. What is the role of the end-users?
4. How will their role change over time?
3. How are the dead kept alive and commemorated?

2.2 The company

Loop-biotech is a start-up in Delft and launched the Cocoon on September 14th, 2020. They designed the first working prototypes and are now building the first batch of coffins. They are currently scaling up the business. With the factory as the newest addition, the production aims to grow coffins constantly.
The research questions for this paragraph are:
1. How are Loop-Biotech and the current coffin reviewed?
2. How is the current coffin produced?
3. How does the current coffin perform?

2.2.1 Brand values

As mentioned in the 'company introduction' (1.2) the vision of Loop Biotech is explained in a purpose, ambition and objective. Its purpose is to "Enrich nature using living material instead of polluting our environment with dead materials (Loop-Biotech)" and to "create biodiversity, feed the earth and sprout new life (Loop-Biotech)". The ambition is to restore "Our human-nature relationship", which they explain as "We are here to restore nature. We do this by bringing human nutrients back into the cycle of life in the most natural way: with a living mycelium-based coffin" (Loop-Biotech).
The objectives for Loop is to grow its business and create "A worldwide innovative burial trend and culture"

User reviews describe the brand DNA as eco-conscious, brave, pure and humble. This brand perception comes close to the vision Loop has.

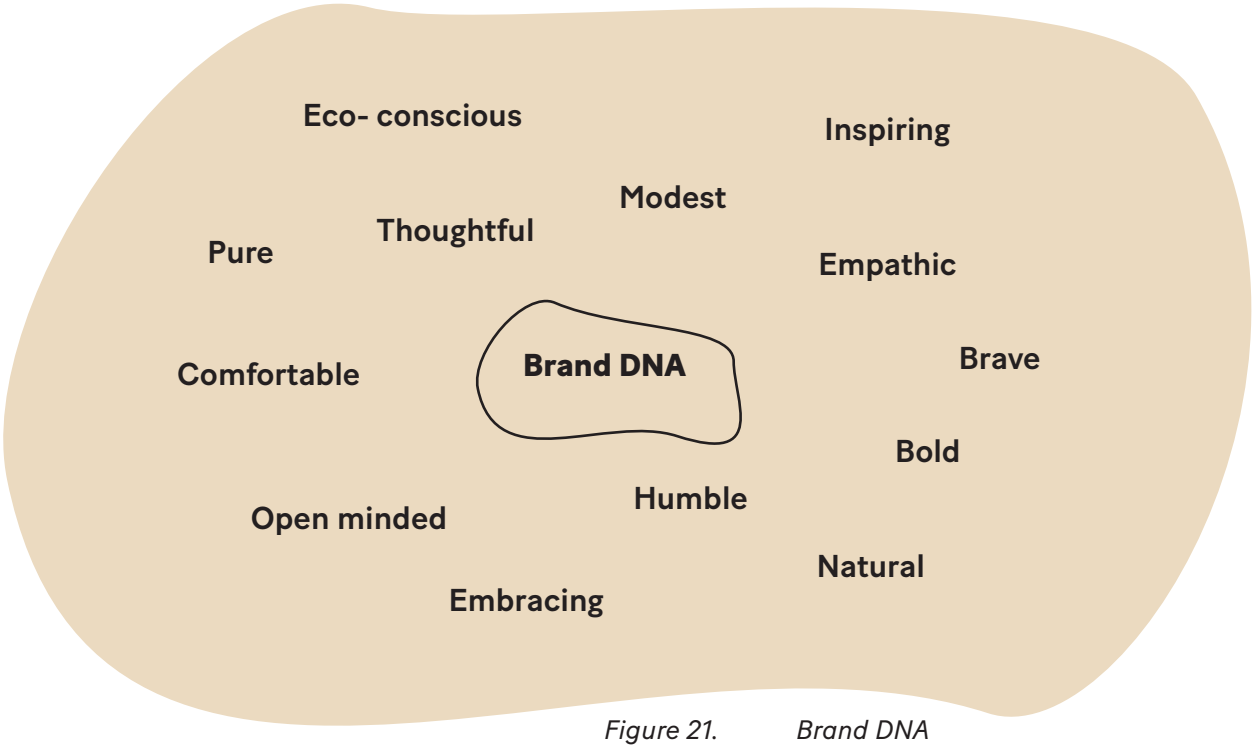


Figure 21. Brand DNA

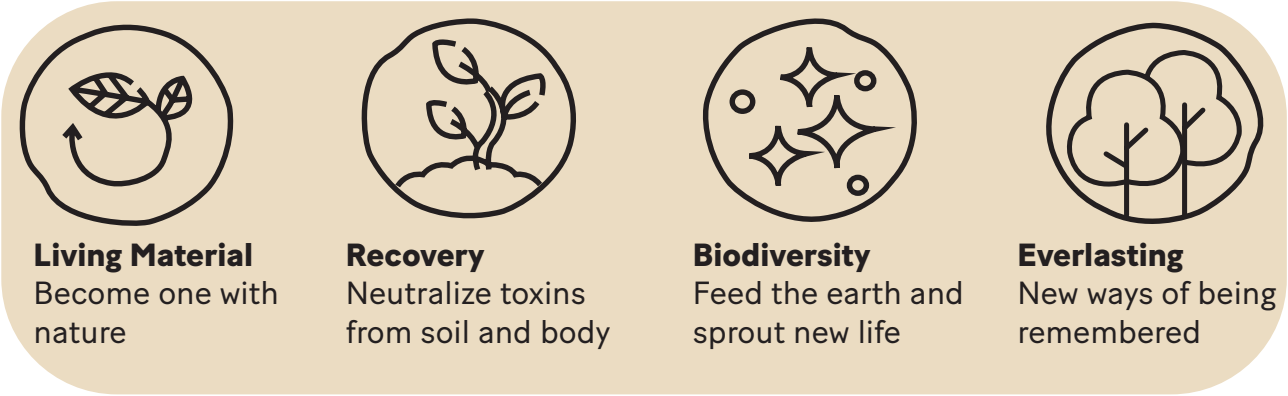


Figure 22. Unique selling points Loop-Biotech

Unique selling points
The unique selling points are nature-oriented due to the qualities of the mycelium.

- Because Mycelium is a living material, your body can become one with nature again.
- The material 'eats' and neutralises everything that it encounters. In the human body and soil, lot of toxins are present. The mycelium neutralises these toxins.
- The mycelium feeds the soil, resulting in biodiversity and creating new life.
- Because the material continues to grow, the person will have an everlasting mark on this earth. This experience is a new way of 'being remembered' for the next of kin and the deceased.

Currently, the human-nature relationship is under a lot of stress, and people feel the urge to restore this relationship. The current Loop coffin production and burial is a natural process, which speaks to a lot of people.

2.2.2 The product

Loop's current product is the Loop Cocoon. This coffin consists of five components; the lit, the handles, the cushion, the bottom and a moss layer.

The current coffin design is based on the form follows function, a design principle related to industrial design. This principle means that its intended function should mainly drive the shape of a product.
The dimensions and shape of the coffin are directly related to the dimensions of an average hearse and grave. These spaces are all square-shaped, and so is the form of the casket. Functionality comes first aesthetics comes second.

2.2.3 The Growing process

How is the coffin produced? The production process in this case is unique because the coffin is grown. For the full growing process see the appendix.

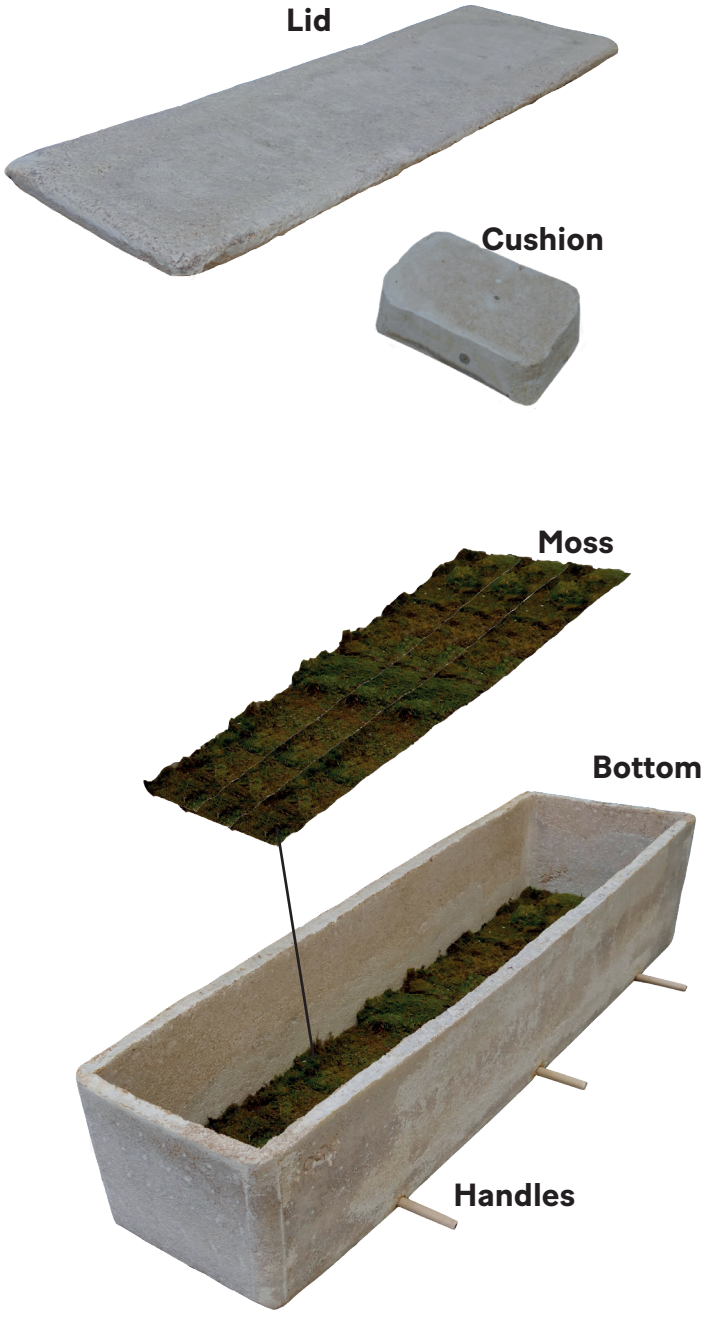


Figure 23. *Currint Coffin parts*

Figure 24. Current Coffin aesthetics

2.2.4 Aesthetics

Images show the typical aesthetic elements of the Loop Cocoon.
The research question 'how is the current coffin reviewed?' is answered through collected data from consumers feedback and personal preference, the characteristics are critically reviewed. The consumer's user feedback is elaborated on in chapter 2.2.5 in this report.

Square shape
The shape is an elongated rectangle. Visitors make comparisons to a refrigerator or a standard wooden coffin. Due to the fragile material, it needs special handling, but the shape does not reconcile this. The coffin is handled as an ordinary coffin but requires a specific approach.

The form is the opposite of organic or natural. The coffin must fit all similar-sized spaces, like a mortuary, graves, and a hearse's interior. All these spaces are rectangles and relate to the square shape of the current coffin.




Figure 25. *Current Coffin aesthetics*

The lid
The top lid is a plate with rounded corners. It is one seamless piece with a bottom thickening part to make the lid fit the bottom.
It is a horizontal piece during production, but it curves, shrinks, and bends after sitting for three months because of complete dehydration.
The 7 cm thick lid contributes to a fragile appearance. Consumers receive the lid as lightweight, sturdy and users are concerned it might break, crumble or blow away.

Round corners
All edges and corners have a 'fillet'. The rounded edges and corners have the desire to make the design more organic and less square-shaped. But since these edges have a small radius and disappear in the overall shape, the willingness of Loop to express naturalness is not met.

Moss
The moss inside contributes to the natural experience. It has a soft and sweet feature and gives the sense that people are coming to lie down in a piece of nature. The green colour and natural material contribute to the experience of the livingness of the mycelium coffin. Additionally, when one opens the coffin with the moss and pine cones inside, a recognizable scent meets the nostrils.

Material
The material mycelium changes over time in colour and look and feel. The longer it sits, the more yellow and sometimes brownish it gets. Right after the drying phase, the colour is white, looks fluffy and cloudy, and looks inviting to touch, pet or break. Consumers compare the material to styrofoam, rice waffle, velvet textile or chipboard depending on the material status.

Conclusion
Personal interpretation of these insights concludes that the aesthetics of the coffin are improvable. The coffin can be interpreted as ordinary and even a bit cheap and cracky. It looks like the product has not completed its design process and is still in the prototyping phase.
Other consumers' interpretation depends on personal taste and style but concludes it needs improvement. However, the unique idea of the material overrules the opinions about the aesthetics and creates a positive and enthusiastic response. This enthusiasm is because the consumers who bought the coffin so far are early adopters and are aware that the company is still a startup.

2.2.5 Product experience

The feedback presents how the current coffin is perceived. Additionally it answers how the current coffin performs. The consumers' experience of the material and the coffin is not only based on the product's sensory characteristics per se. Experience also consists of the feelings it awakens on a spiritual level. Emotions are sometimes hard to explain or to put into words but contribute to the product perception.

Figure 26. *The current Loop Cocoon*

Material
Material or product experience divides into four categories/levels.

- Sensorial experience (what do you see, feel, smell - cold, smooth, shiny)
- Experience of meaning (personality -modern, sexy, cosy)
- Emotional experience (how does it make you feel - feel amazed, feel surprised, bored)
- Performative level (what makes it people do - rip it, pulk it, smell it, throw water over it).

Sensorial experience
Product perception is often biased by preconceived ideas about product properties and is affected by the consumer's judgmental frame of reference (Schifferstein, 2001). Research and interviews showed that the current coffin users make remarkable comparisons with the coffin and the unique material:

- Rice waffle coffin
- Refrigerator
- Concrete box
- Styrofoam box
- Oak coffin
- Dead material

Experience of meaning material
The experience of meaning of the material is different per person. Some say it looks a bit clumsy and crumble. Others described the white skin as high end and smooth, like a Tesla under the coffins. Some consumers like the white skin, but others find it unnatural. This is dependent on the personal preference.

Emotional experience material
Seeing the material clarifies to the consumer where their body will go when they have passed away. The mycelium will take care of their body and continue to live. They will use their whole body as a nutrient. For some this idea causes comfort, grief and sadness. Seeing the coffin makes the consumer aware of the following steps that are about to happen. Others finds the demolishing element scary and dirty and do not like the idea of complete decomposition.

Performance material
The unfamiliarity with the mycelium causes people to categorise and compare the material with a material they know. As shown above, rice waffle, or styrofoam are undsturdy comparisons, of low quality and out of context with the funeral industry. A result of this comparing is consumers questioning the performance level of the product and material. Research and collecting feedback showed there are doubts about the coffin structure. Questions arise like, will it hold the body? Is it waterproof (for body fluids leaking)? Won't the lid blow away? How do we lift the body inside the coffin because the walls look like they are not built to lean against? Does the material really work?

Figure 27. Current coffin material

What do these questions mean?
These questions show the consumers expect a certain level of quality at the end of life. They presume the attention and quality they are used to in life and similarly design their end of life. They want the product to be 'high-end' and of high quality.
They want the coffin to express the lifestyle they lived and show their personality through the design.

Conclusion material experience
The material experience differs per consumer. One may be familiar with the material, where others are curious what the mycelium is or despise the idea completely. As a consequence of the unfamiliarity with the material, irrelevant comparisons are made. This unfamiliarity contributes to the feeling of low quality of the coffin with the consumer and can cause disappointment or insecurities about the performance.

Shape

Sensorial comparisons shape

The coffin has a similar shape and size compared to an ordinary coffin. In this case, the product perception is biased by preconceived ideas about coffins and is affected by the consumer's judgmental frame of reference.

Research and interviews showed that the reviewers make comparisons with the coffin shape and how it should be handled.

The coffin is compared to a standard coffin. But it is not. So it should not be treated and perceived as such. One will not push a body on a board because it is not perceived as something to push but to lift.

The consumer wants to differentiate themself from the ordinary oak coffin because they don't want to be normal. A unique coffin is how others can commemorate the deceased and it helps as a mnemonic device for the next of kin.

Experience of meaning shape

Consumers experience the shape as dead, unnatural, cheap and abstract.

Others find it extraordinary and high end. It depends on personal taste and preference.

Emotional experience shape

The emotions that awaken when first seeing the coffin are hard to describe by consumers. Overwhelmed, sad, surprised, but also certain happiness or inner peace are words that came up. Also, there is curiosity and doubt about the coffin. How is this made? Does the body fit inside the coffin? Will it hold the weight?

What do these question mean? The unfamilarity with the coffin causes insecuties. The evoked emotions depend on the person, either the close bereaved, the deceased or the undertaker. Every stakeholder has their personal experience with the encountering, but most reactions described curiousity, insecurity and a level of doubt.

Performance shape

Feedback Undertaker:

- It happened when I pushed the coffin inside the hearse. When I pushed the wall, it broke, and my hand went through the wall. I touched the head of the deceased inside the coffin.
- When we lifted the lid onto the bottom to close the coffin, a piece of the lid broke off. It happened to be a blessing in disguise because the widow wanted to take the piece home as a memory, but as an undertaker you do not want this to happen.

The stories above show the current coffin does not perform as it should. The structure and shape are bottlenecks of the product.

Conclusion shape

The consumer chose this coffin because of its unique selling points concerning the material qualities. Because of the squared shape, the coffin is perceived as a standard coffin and used like that. This wrong interpretation can cause

- Failure of the product and a feeling of dissatisfaction with the end consumer
- Disappointment because of the unnatural and standard appearance
- Doubt about the performance level

Figure 28. Current coffin shape

2.3 The material

To understand the material mycelium and redesign the coffin, this paragraph follows the material driven design method (referred to as MDD). Since the research aims to understand how the mycelium coffin can be redesigned, it is key to explore the material mycelium. The research questions help explore mycelium qualities since they seem to highly influence users' experience of the product.

1. What are fungi based materials and products, and how are they developed?
2. What would the material's unique contribution be to a coffin?
3. What are the material's unique technical/ experiential qualities to be emphasised in the final design?

Most research questions are directed towards the first two phases of the MDD method as the third and fourth step depend on the outcomes of the prior two and are, therefore, somewhat more general and will not be included in this chapter.
They will be included in the following chapters of the design process.

Figure 29. *Material samples*

The MDD is a method to understand a material and characterise it both technically and experientially to articulate the material's unique role (in contrast to alternative materials) when applied in products and improve the current coffin design. (Karana, 2015)

The MDD method (figure 35) is used when the design starts with the material. In this case, mycelium.
This method consists of four stages that provide a framework for the research and development of a material;
(1) Understanding the material,
(2) Material Experience Vision,
(3) Material Experience Patterns and
(4) Designing Material/Product concepts

What does the MDD include?

- Tinkering with the material to get insights on what the material affords
- The technical/mechanical properties
- How it can shape/ embody in products
- Material benchmarking to position the material amongst similar and/or alternative materials
- To generate insights on potential application areas, emerging materials experiences and other emerging issues within the design domain.
- User studies to explore how people receive the material, how it is appraised (i.e., experiences related to aesthetics, meanings, and emotions), as well as what the material makes people do

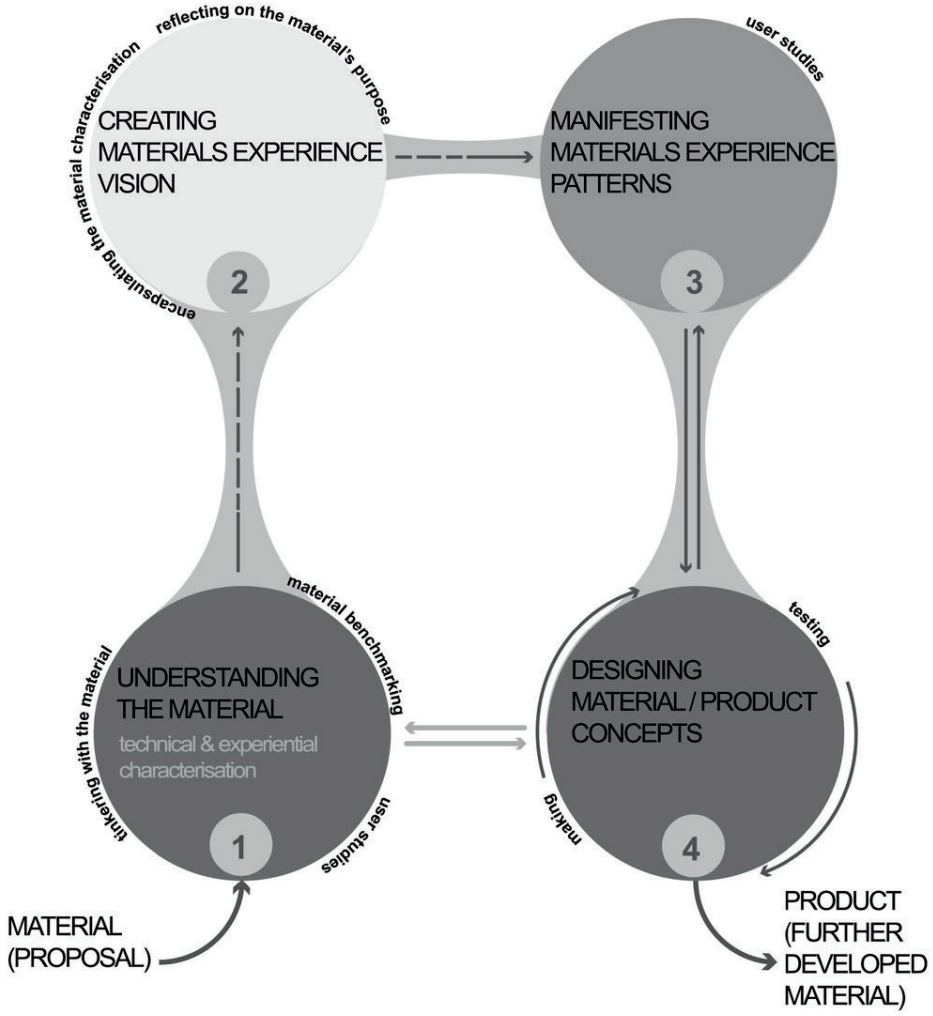


Figure 30. Material-driven-design method

Figure 31. Mycelium composite (left) Pure mycelium (right)

2.3.1 Step 1: Understanding the material

Mycelium is the network of interwoven, thread-like hyphae that constitute the vegetative part of mushrooms. A 'hypha' is the most basic developmental unit of filamentous fungi, which grows by extending and branching their hyphae into a substance (Kavanagh, 2011).
Mycelium-based materials were introduced almost ten years ago by Ecovative (Ecovative, 2016) and can be divided into two forms, pure mycelium and mycelium composite.

- Pure mycelium is grown by harvesting a liquid culture of mycelium (pure mycelium) (Haneef et al., 2017; Holt et al., 2012).
- Mycelium composite is a material in which the mycelium grows around the substrate particles, for instance, agricultural waste (e.g straw), to form a solid shape, resulting in a bio-composite (Jiang, Walczyk, Mooney, Putney, 2013). Mycelium-based composites are fabricated by inoculating an individual strain of fungi in a substrate of organic substances (Holt et al., 2012; Jones, Huynh, Dekiwadia, Daver, & John, 2017).

Performance
By planting mushrooms, toxins can be cleaned up;

- asbestos,
- arsenic,
- plastics,
- lead,
- 2300 kg mercury from dental filling,
- BPA,
- Heavy metals,
- polycyclic aromatic hydrocarbons,
- PAHs or TNT

This cleaning up is called mycoremediation. They break down pollutants in the environment. The network secretes enzymes that contain contaminants into other forms. Other advantages of mycelium are: inexpensive, energy-efficient, good for the soil and the unique growing process; They don't need light, they use radiation instead. Disadvantages are; it takes time to match the pollutant to the environment and is not well studied yet. Also, the material is a delicate organism that needs a careful approach to design and produce with.

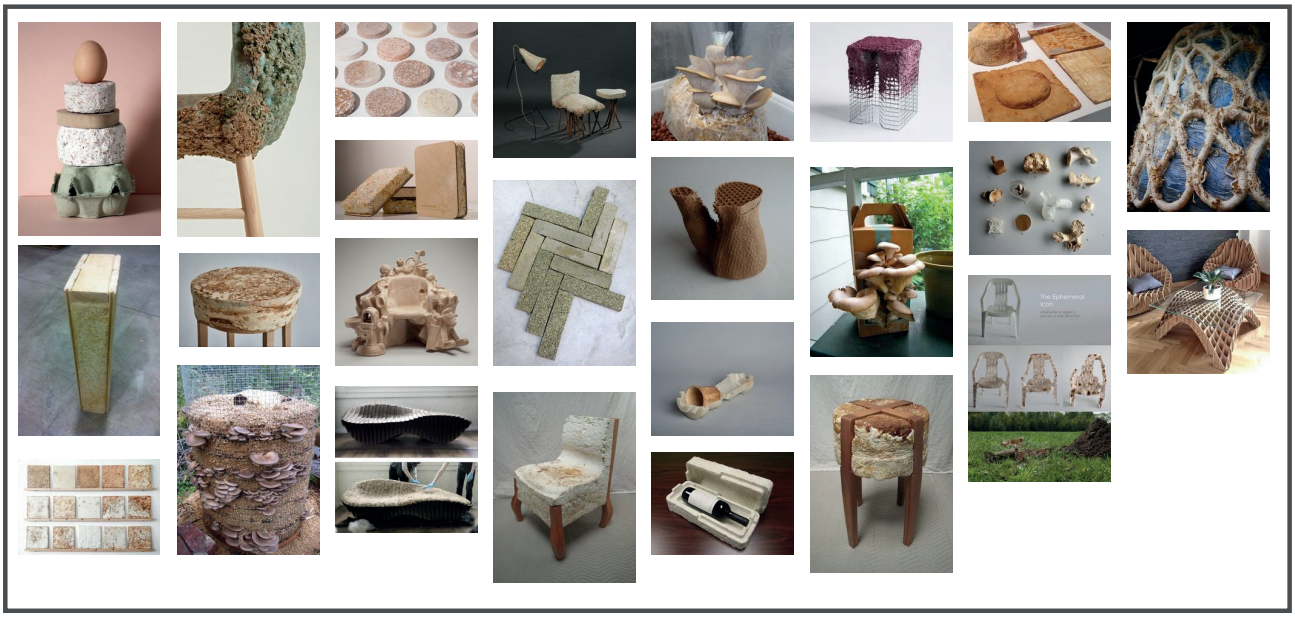


Figure 32. *Mycelium orientation*

Orientation
First current designs with mycelium are analysed on designed encapsulation and the interaction they provide.
Below current products and projects with mycelium based materials are visualised.

Insights
- All mycelium objects are grown in a mould.
- Mycelium can be grown in almost any shape. Nevertheless current shapes are basic, round, square or triangular. Only a few have organic and natural shapes.
- Only products known to mankind are reproduced in mycelium.

Tinkering
Tinkering with the material will help understand the material's behaviour. Livingness as a material quality suggests a fundamental shift in the way we design and everyday cohabitation and interaction with objects that sense, grow, adapt and die (Still alive, 2020). The tinkering confirmed this fundamental shift that is required.

Growing samples and testing the optimal circumstances give insight into creating the best material results (see appendix B for elaboration). Testing the samples with users and triggering reactions formed a deep understanding of the qualities and obstacles of the material. The insights gathered are the basis for the material experience vision in step 2.

Tinkering with material #1
A test to let the mycelium grow around bioparticles. Not in a mould but around another material.
Tinkering with material #2
A test to grow mycelium with compression applied to test flexibility, quality of skin-growth and brittleness.
Tinkering with material #3
Derived from test 1 and 2, it is tested what fibres/composites, grown under medium pressure, give the highest tensile strength and material quality.

Insight
- The basic instinct of the material is to grow with other low-density substrate particles. It likes dark, crowded spaces for optimal colonisation.
- The composite should provide a moist environment as nutrients for optimal growth. Contamination of the mycelium (dark spots in the white material) will weaken the stiffness and quality and should be prevented.
- The particles influence the structure of the composite. Tiny fibres stimulate better colonisation; the easier it is to pick up, without fibres crumbling off. However, too small fibres will weaken the structure. The research tested hemp fibres as best for the composite.

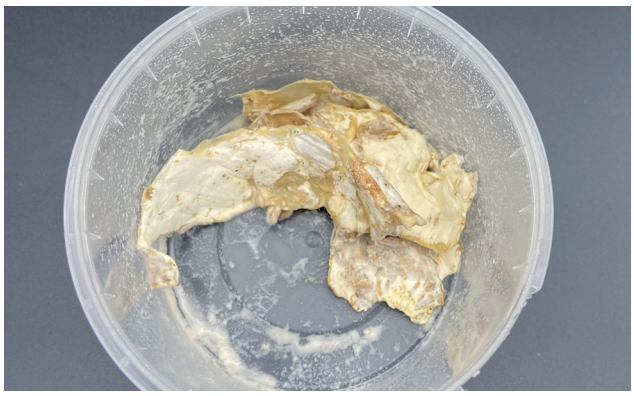


Figure 33. Details tinkering #1


Figure 34. Details tinkering #2


Figure 35. Details tinkering #3

- The smell of the structure influences the final grown composite and contributes to the material experience.
- The more pressure applied during growth, the stiffer but more brittle the material will be. Medium pressure will give the optimal material quality with high flexibility and optimal skin-growth.

Technical characterisation
Technical information on the strength, stiffness and brittleness of a material is commonly presented in a stress-strain curve.

Stress (N/m2); the ratio of force that is applied to the cross-sectional area of a material.
Strain (%): the percentage of elongation of the material (ΔL/L) when under stress.
Material samples from 'tinkering with material #3' are used to test the strength and flexibility of the mycelium. Together with the information provided by Ecovative created a complete overview of the capability of the mycelium composite.

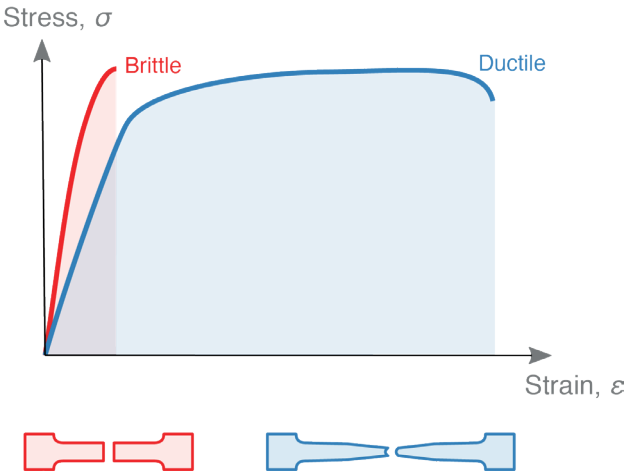


Figure 36. *Stress-strain curve*

Results /insights
1. Tensile strength (Pa or N/m2): the maximum amount of stress that a material can handle until fracture.= 100–200 kPa)
2. Yield Strength (Pa or N/m2): the highest amount of stress a material can handle without a permanent change of shape (plastic deformation). = 27 kPa
3. Young's Modulus (Pa or N/m2): Also known as the elastic modulus and defines the relationship between the stress and the strain (proportional elongation). = 66.14–71.77 (MPa)

Discussion
- Although the results give some insight into the material strength, the tests could not be executed by the student according to the test standards, so results cannot be directly compared to the industry's values.
- The clamping of the material caused issues because of the softness and brittleness of the material. The samples could not be fastened between the clamps.
- Heat pressed was not taken into account, but research showed that this improves the material quality significantly. This is not considered relevant because the heat will kill the mycelium organism and prevent the mycelium from growing when buried.
- Other composites could not be tested because the samples already cracked when demoulded (figure 42 the first 2).

Figure 37. *Tensile test samples*

Figure 38. *Benchmark 1: Mycleium in different fields*

2.3.2 Step 2 Material experience vision

Insight from step one formulates the material experience vision.
The vision statement influences the process of redesigning the living coffin.
Bencharks show current products, like the coffin, do not emphasise the actual growing and demolishing nature of the material during production.
Additionally, with fungi based material, it is possible to see and feel the material grow, emphasising the naturalness and 'living' characteristics of the material.
Two benchmarks present
(1) the mycelium products positioned in the current market
(2) renewable, biobased and scalable materials and their applications.

Bencharkt 1 (figure 43)
The first benchmark shows mycelium products positioned as design, architecture, fashion, packaging and art. Even though, made from the same material, each product emphasises different purposes, functions, interactions and material qualities. This is visually derived from the images of the products.

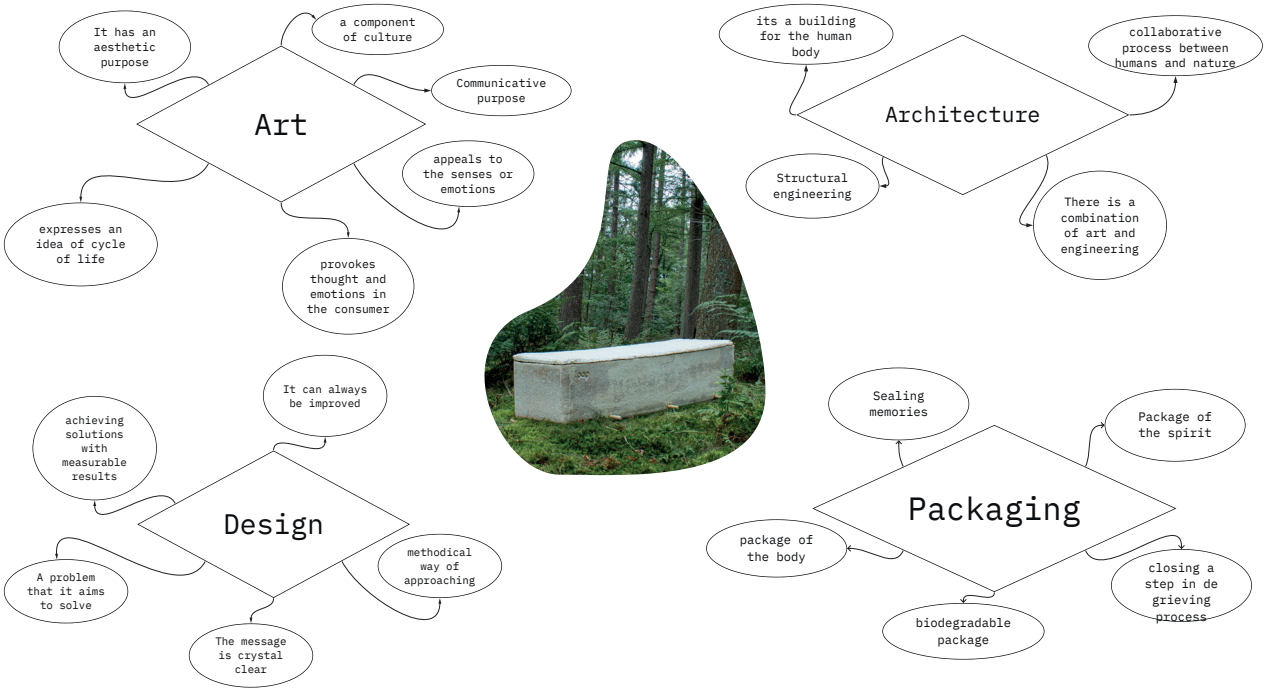


Figure 39. *Insights from Benchmark 1*

Insights

The coffin can be approached and positioned in different areas. Why is it art, architecture, packaging, or product design? This question was answered and stimulated an understanding of the positioning of the product.

This positioning allows satisfying the consumer. The coffin can be seen as art because it provokes thoughts and emotions in consumers. It can be positioned as design because it achieves a solutions with a measurable result. It is seen as architecture because it is a building for the human body.
And art, more spiritualy, because it seals a spirit, memory or closes a step in the grieving proces.

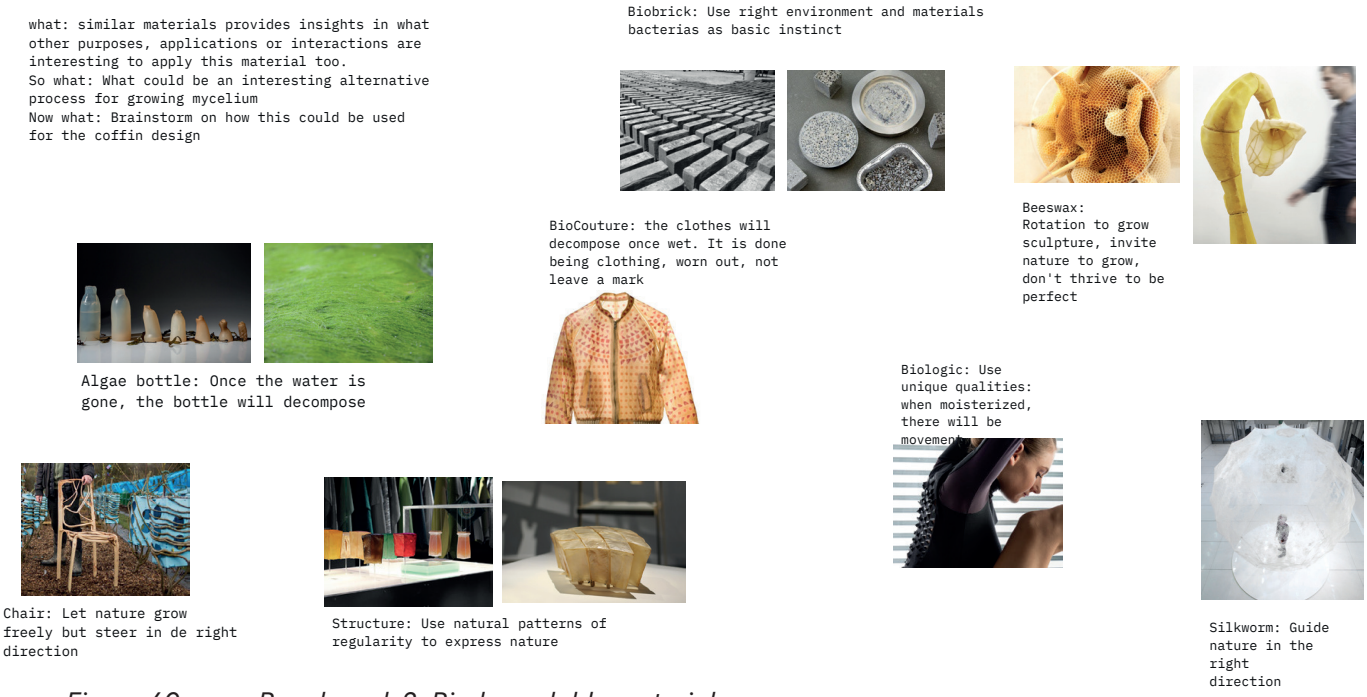


Figure 40. Benchmark 2: Biodegradable materials

Benchmark 2

The second benchmark shows renewable, biobased and scalable material and their application. Information is described on: the material source, the technical and experiential qualities, the applications, activities and ultimate purpose.

- An algae water bottle will decompose once the water has left the bottle. The algae will no longer feed on the water and vanish.
- A chair, grown with benches of trees, steered into the direction with the help of a mould.
-Biobrick has a self-repairing character. The living bacteria are used as an opportunity to glue cracks together.
- BioCouture creates fashion based on fermentation. Once the clothing piece is worn out, it will decompose when in contact with water.
- The shape of assembled pieces is inspired by natural patterns of regularity, such as reptile skin or flower seeds structured.
- The beeswax sculpture is created in cooperation with the bees. The queen bee is placed in the middle. After introducing the rest of the hive, the sculpture is rotated regularly.
- Silkworms create a cloud-like sculpture. By squirming all over the surface and around a framework, they are steered in the right direction.

This information is visually interpreted based on the images and available data from the internet.

Application	Activities	Technical properties	Experiential properties	Purpose
Textile	Seating	Strong	Natural	A bio-material future
Packaging	Carry water	Self-healing	Soft	New production techniques
Construction	Sporting	Lightweight	Inviting	Reproducible
Decoration	Building	Flexible	Rough	Organically grown
Furniture	Protecting	Energy efficient	Transparrent	Showing cycle-of-life
Art				Education about nature
Interior				Communicating lifestyle

Figure 41. Insights from Benchmark 2

Insights

The most favourable characteristics derived from the benchmark provide insights and opportunities for designing with mycelium.

- Using the living organisms basic instinct as an advantage instead of a threat or something that needs to be suppressed can provide design opportunities.
- It invites nature to grow and be perfect in its imperfect way. Guide the organisms in the right direction with the help of a mould.
- There is increasingly more request about biodegradable products.
- Biodegradability can have an educational purpose and spread a message about sustainability and nature.

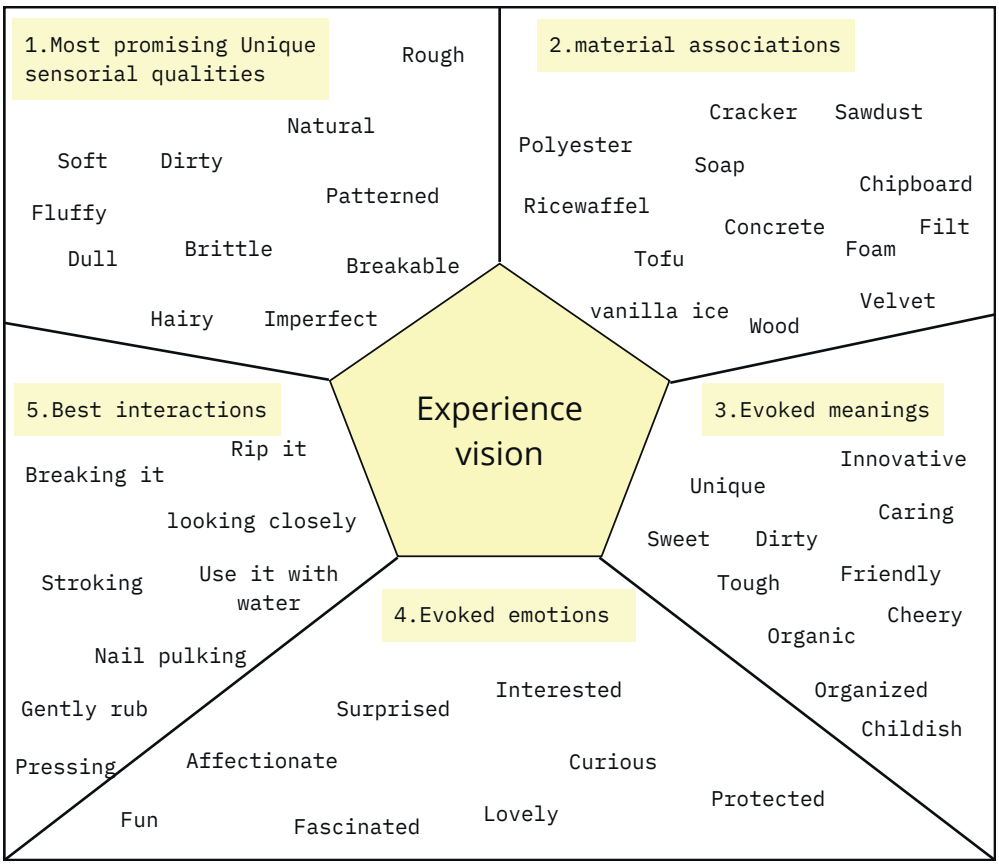


Figure 42. Consumers material experience vision

Experiential characterisation

The phrase 'materials experience' was first coined by Karana et al. (2008), who defined it as the experiences that people have with and through the product's materials.
Material or product experience can be divided into four categories/levels.

- Sensorial experience (what do you see, feel,smell-cold, smooth, shiny)
- Experience of meaning (what if it were a person-modern, sexy, cosy)
- Emotional experience (how does it make you feel-feel amazed, feel surprised, bored)
- Performative level (what makes it people do-rip it, pulk it, smell it, throw water over it). (Giaccardi and Karana (2015))

A test, executed with eight participants, provided insights about the material experience. They were given a mycelium sample and asked to describe their material experience. Below an overview of the most mentioned perceptions and sensorial qualities is given.

Insights

Mycelium materials are solely made of natural substances and can therefore be discarded in nature and enrich the environment. The ability to grow the living material, the visible fibres and sprouting mushrooms give the material a natural appearance. Still, the perfect skin growth and unnatural white colour confuse people who are unfamiliar with the material. Preconceived ideas about material properties cause irrelevant comparisons to other material, often of low quality.

In combination with its brittleness and the tendency to break the material, when interacted with, characterises the material as 'made to be thrown away and invited to touch.

Material experience vision

The challenge is to emphasise the material's instinct and shaping ability and embody this within the redesign.
Create an experience that invites you to discard it in nature through the context of the product and the interaction it creates.

The mycelium is grown in moulds in the existing examples, specifically made not to be demolished by the mycelium. Using hard surfaces and long-lasting moulds. The 'eating' of moulds is described as a disadvantage which could be turned into an advantage.
Additionally, the material is designed not to be touched or interacted with. Though the material invites the user to touch, break or pet, only a visual connection is made. It does not result in a physical connection.
Furthermore, the material can grow into any form possible. Yet in all existing examples, only basic forms are used.

- Sensorial: Imperfections, white surface
- Interpretive: Express naturalness, uniqueness, preconceived comparisons
- Affective: Make people curious and even surprise them, let them learn, engage, feel inviting to touch and connect, use the materials basic instinct
- Performative: Discover the material through the senses

Figure 43. Experiental characterisation

In the existing examples, the mycelium is grown in moulds, specifically designed ***not to be demolished*** by the mycelium. Only hard surfaces and long lasting moulds are used. The 'eating' of moulds is described as a ***disadvantage*** which could be turned into an advantage.

The material is designed not to be touched or interacted with. Though the material ***invites*** the user to touch, break or pet, only a visual connection is made. It does not result in a ***physical connection***.

Furthermore, the material can grow into ***any form*** possible. Yet in all existing examples only basic forms are used.

Figure 44. Material experience vision

2.4 The market

The changing funeral industry motivates Loop to adjust their product design. The constantly moving market inspires Loop to act upon these trends. At the same time they have the ambition to change the market itself. The scope of this research is in the Dutch natural burial market. It is researched how this has transformed and is transforming.

The research questions are
1. How and why is the industry developing?
2. What are the needs for the funeral process?
3. How can a Loop coffin be purchased?
4. What is already available in the current market?

To understand the market it all starts with Loop-biotech, the coffin designer and producer. Below three ways of purchase are visualized. The coffin is sold Business 2 Business and Business 2 Consumer. The first option is via a distributor like the company Unigra. They have different depots where coffins are stored. An undertaker company or individual entrepreneurs can buy the product directly at the Loop or distributors. The end customer will then buy the coffin at an undertaker or directly at Loop.

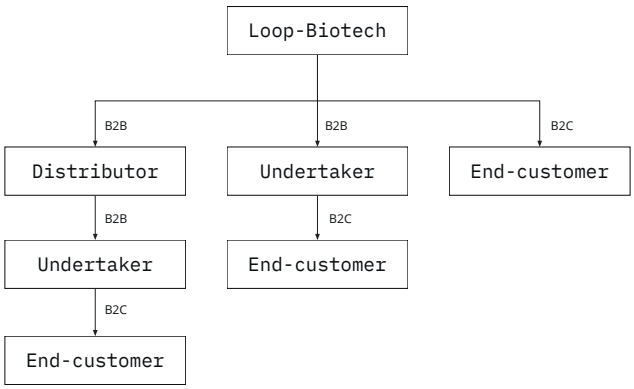


Figure 45. Business model Loop

Looking at other companies who offer a coffin or other body disposal practices, a scope was made. There are four mycelium vessels centered in the middle. Surrounding that, biodegradable vessels are shown. And in the outer circle undertaking services are visible.

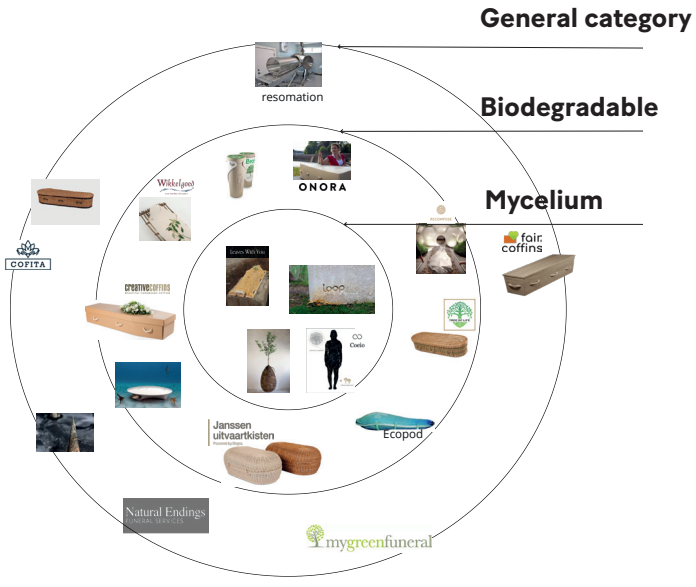


Figure 46. Competitor scope

2.4.1 Desktop research Funeral Industry
Death and funerals are inevitable parts of our lives; a significant amount has been written about. This literature analysis researches different domains. From the funeral industry and the influence of the coffin.

Funeral ritual
In the mid-nineteenth century, managing the rapidly expanding number of corpses had to be controlled and rationalised. Business, the municipality, or the church, could exercise this control leading to three pure types of funeral organisation (Walter 2005).
- commercial
- municipal
- religious

But nowadays this industry is changing, ways of organising funerals (commercial, municipal and religious) are mixed. But what are the outcomes of these new mixes, why is it done and how is this developing?

Rituals influence the funeral industry for as long as we can remember. Religion played a significant role in creating these rituals. However, according to Paul Dekker, the Netherlands is one of the more secularised countries in the world. In the course of secularisation and individualisation, traditional religious rituals have fallen increasingly out of favour (Bernts, Dekker, & de Hart, 2007), resulting in a 'quest for new rituals' (Wouters, 2002).

People often cramp at the moment of death, causing all creativity and ingenuity suddenly to disappear in a head full of emotions and sadness. The funeral industry was responding to this, with the result that many funerals are held in a moodless space and in a way that does not fit the life that someone lived.
But funeral trends are upcoming such as personalisation, environmental awareness and a high quality during the funeral service


Figure 47. Personalisation

1. Personalisation
In particular, in the death rites, experimentation and innovation are taking place (Venbrux, Heessels, & Bolt, 2008), facilitated by the consumer-oriented undertaking business and leading to more personalised mortuary rituals.

In the last two decades, the Netherlands has seen increasingly informal (Wouters, 1990) personalised dealings with death. Initially, pleas for funeral reform from those dissatisfied with the standard offer went in partnership with the notion that people could regain control and opt for ceremonies of their own choice through 'do-it-yourself' funerals (Enklaar, 1995; Sax, Visser, & Boer, 1989). Traditions originated from religion, are adjusted to personal wishes. They are reflecting the personality and the lifestyle of the deceased and close bereaved.

Figure 49. Environmental awareness

Figure 48. Quality

2. Environmental awareness
Although many different factors may contribute to the changes in the funeral industry, environmental awareness and the subsequent concern about ecological implications of traditional burial and cremation are seen as some of the most prominent factors. Innovative methods of funeral arrangements had become known, which were officially prohibited.

Environmental awareness also explains the rapid growth of natural burial grounds (Klaassens, 2010). Natural burial is an innovative sustainable burial form that evolved over the past years and has become more popular.

3. Quality during funeral service
Funerals are becoming the "last minute of fame". The coffin, theme and personal service contribute to this last moment. So only the best is good enough. The funeral is compared to a wedding where no costs and efforts are saved, and quality is guaranteed. In some ceremonies a statement is made.

Depending on the choice of the coffin, symbols, speeches, rituals, or other elements during a ceremony can determine the quality of the funeral. Close bereaved people feel the desire to take care of the deceased spiritually and physically and provide comfort.

Figure 50. *Bookcase and Trial lying*

4. Other coffin trends
In the past, the main function of a coffin was containing diseases. Later on, a coffin was determined according to the class system, the rich got a more expensive coffin and used it to make a statement.

Now a coffin is associated with a particular lifestyle. Death and the coffin is becoming a more accessible topic to talk about and less of a taboo.

Looking at trends in other countries, a few unusual innovations stand out.

- For example, in New Zealand, people *build their chest themself* and physically face death.
- Another trend is *'trial lying'* in Japan. Before buying a coffin people can lie in it for a couple of hours to get a feeling of where they will be when passed away.
- Coffins sometimes also have a different function before it is a chest. For example, a bookcase or folding screen. These coffin sellers are called the *coffin club*, 'Makers of Fine, Affordable Underground Furniture'

The opinions on these innovations are divided. It can be found unrespectful and be at odds with our decency standards. (uitvaartmuseum tot zover, 2019)

Conclusion
1. How and why is the industry developing?
2. What are the wishes for the funeral process?

Depending on the choice of the coffin, symbols, speeches, rituals, or other elements during a ceremony can determine the quality of the funeral.
Funerals and coffins nowadays emphasise the identity of the deceased. The quest for unique alternative coffins was a logical consequence of regaining control and opting for the consumer's ceremonies.
A quest for new forms is upon us, and innovation is undeniable. The market is changing rapidly, and breaking taboos is liberating, but it is also at odds with decency standards.

2.5 The end-users

To answer the research questions in the best possible way to obtain the goal of the research, literature, interviews and podcast were analysed. The needs and desired experiences of the stakeholders were extensively examined. These insights were used to create the design direction. The research about the end-user is elaborated on in this paragraph.

1. What are the needs of the end-users?
2. How will their needs change over time?
3. How are the dead kept alive and commemorated?

Three types of users are distinguished: close bereaved, visitors and the deceased. The meaning of a funeral is different among those three types of users.

Close bereaved:
The close bereaved is the family who is closest to the deceased. There can be deep involvement in the organisation. They often have a responsible role, like carrying the coffin, giving a speech and being present during the whole process. They often express their emotions, share grief with each other and the visitors, and share their memories.

Visitors:
This group has a more passive role. They are often present at the funeral to pay their respects to the close bereaved, deal with their loss and support each other. They also express emotions and share their grief and commemorate the deceased.

Deceased:
This person either chooses to deliver personal input and make arrangements beforehand. Or they will let the close bereaved make arrangements. Though they won't be physically present, they sometimes choose to tell a personal story or share a vision or hand out gifts. Something that will symbolise the life they lived. These actions are to support the family or show what was important to them.

Close bereaved

Visitors

Deceased

Figure 51. End-user group

2.5.1 Desktop Research end users

Research has shown that funeral experiences help in the grieving process. They can be effective in helping people walk through the early days of grief after the death of a cared-for person, essentially helping family and community walk together as they carry their loved one "home" (Barnard 2019). More importantly, stress during this process causes a negative impact on the experience amongst the end-users. This indicates that the need for a positive experience and support in the funeral process is high during these times.

Quartier and Venbrux (2011) explain our efforts to make something of the funeral ceremony: "We commemorate, we try to keep the dead alive through memories. A unique event is memorable. That's how we exorcise death." (Quartier and Venbrux, 2011, p. 79). Why and how are the dead kept alive and commemorated, and how can this be done better?

Emotions are sometimes hard to express and put into words. So the end-user group designed rituals to shape emotions they experience. During funeral rituals, grief expresses itself in symbols and acts because the emotions someone experiences can be better visualised and shared.
- An example of a symbol is the coffin itself. It symbolises the deceased.
- An example of a ritual is the casket closing ceremony. The coffin provided the tools for rituals and interactions. A ritual that will help take the next step in the process.
- Another ritual is the funeral ceremony itself. The practice seeks stability in exceptional situations and has a commemorative function in saying goodbye.

Grief
Funeral ceremonies are about processing grief and remembering the dead. But grief is not a moment in time, a thing that needs to be fixed. It is chronic, an experience, or also called a multitasking emotion.

In the context of bereavement, grief is an important phenomenon. According to grief experts, a funeral ritual has an essential function in grief since accepting the loss becomes more accessible when the bereavement is made explicit, for example, through an open coffin and a beautiful, unique last ceremony. (Falconer, K., Sachsenweger, M., Gibson, K., & Norman, H., 2011).

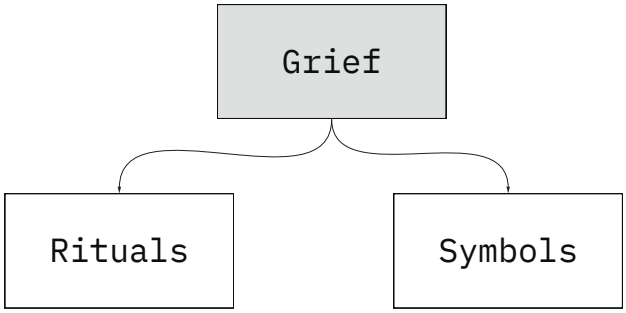


Figure 52. grief, rituals and symbols

Rituals
For several years now, there has been a growing focus on 'rituals'. (T. Bernts, G. Dekker, J. De Hart, 2007). And in the case of dealing with dying and death, rites do two things in particular:

- they remember
- they project

They are media of memory and media of projection. The living and the dead are not set apart by an established boundary; they are linked by the funeral practices, death rituals and memorialisation of the dead. (Lloyd Warner, 2005)

Rituals slow down life. They interrupt the speed and ask for relative stagnation. The practice seeks stability in exceptional situations and has a commemorative function. "In crises, we need to restore cohesion, connectivity that keeps us from falling apart. Rituals pre-eminently contribute to this connectivity.

Rituals are, therefore, performative acts. They express "something else", and this "other" is the cultural sense dimension, the reservoir of beliefs.

Every ritual - be it so personal or even idiosyncratic - is a design and therefore not spontaneous or instantaneous. It is a longing for form, a hope for a shape for the great sorrow, for the grief. (jean-Pierre wils, 2009)

An example of rituals with a coffin is the moment the close bereaved encounter the body. End-users sometimes find the confrontation with the deceased body to help realise the reality of the loss as it removes any doubt about the person's passing. (Falconer, K., Sachsenweger, M., Gibson, K., & Norman, H., 2011). This ritual creates a memory that will not be forgotten soon because of the unusuality of the moment.

Symbols
Grief occurs on a symbolic level, not an intellectual level. During rituals, this grief is expressed in symbols and acts. Why symbols? Visible objects and images are worth a thousand words and are remembered better. They are, therefore, an essential part of rituals and commemoration. (Venbrux, E., Quartier, T., 2011)
Symbols are used for the desire of reconstructing the deceased's identity. (Francis)

2.5.2 Podcast

The podcast 'dag voor dag' by Liesbeth Rasker discusses mourning and death. End users who lost people are interviewed about how they experienced the funeral process and the mourning process. What are differences in loss, grief, and subjects such as crying, pain, and pursuing living and mourning? And how do they keep the lost ones still 'alive'. How do they commemorate, remember and hold on to those memories?

Below, the most valuable stories and insights are listed. Overall it was remarkable when Liesbeth asked the person to tell the story about the funeral process and what they remembered most about that time; almost everyone mentioned it went by in a daze. But they all remember specific details, such as choosing the coffin, closing the coffin, how the dead body looked, how that would make them feel, some remarkable stories, and fun or notable events.

Figure 53. Dag voor dag podcast

- Coot van Doesburg: I keep my lost ones alive in objects all around me, the house and the garden. I have a tree in my home in France. My best friend is scattered there. Every year on his birthday, I will go to that tree with a wine bottle and pollard the tree. I talk to him and make jokes and tell him; watch out, this might hurt a little!

- Frans Rasker: My wife died about 15 years ago. But every morning and night, I will light a candle under her picture in the hallway. I constantly talk to her, and sometimes she talks back. Or when I am in doubt, I ask her to help me out, and the lights flicker. As a sign that she is still present, I see that she is still around me and thinking about me. But this 'keeping her alive' also prevents me from going on with my life and finding new love. Because she is still so present, it feels like cheating.

- Gijs van der Sanden lost both his parents at the age of 23. He turned this loss into a career opportunity and wrote a book about mourning. He only started mourning at the age of 30, seven years after the loss of his parents. He would visit the graves every year, would come home and put on a tv-series. But he learned that, after an activity like that, he must take the time to feel. With the help of therapy, he knew mourning is feeling it, feeling emotions. Let the grief breathe. Let the thoughts move freely because sadness is an organic living thing in your mind. And by letting it move, grow or shrink, this helped him deal with it.

- Lara Geijsen lost her father due to an addiction. She had not seen him for ten years. But the week before his death, she visited him and concluded that all was forgiven for providing him with the last good days. The funeral was what bound them together. Looking for coffins, giving them something to do together was a positive distraction.

2.5.3 Interview Users

In addition to the literature research, and the podcast, the end-user group is interviewed. Conversations with the Coffin-buyers gives insight into the different domains of burial. The research questions are researched by asking questions: How did you experience situation X? How do you imagine situation Y to be? Their wishes, motives and expectations for the coffin are discussed.

- I like the idea of enriching nature after you die. My body is still of value then for something. (interview Visitor Loop)

- I think connecting the end and beginning naturally will help me also during my death process. I have the comfort of knowing that nature will hold you in a warm embrace after your death. (interview Visitor Loop)

- Via this coffin, I want to show and teach people the importance of the earth and sustainability. Maybe I can have an exemplary role one last time. (interview Visitor Loop)

- By becoming a substantial part of nature, I can show what I stand for personally and hopefully enable proper closure for my family and friends.(interview Visitor Loop)

- The idea of maybe one day turning into a tree, an object that can touch, comforts me. (interview Visitor Loop)

- The coffin is a vessel. It is a transition from earth to another place (Coach meeting Dicky Brand)

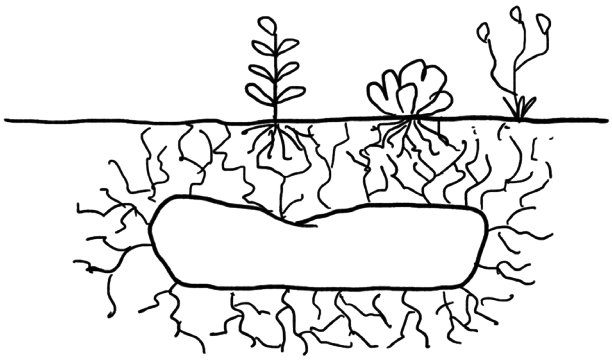


Figure 54. *Enrich nature and create biodiversity*

2.5.4 Conclusion End Users

So, looking back at the research questions,
1. What are the needs of the end-users?
2. How will their needs change over time?
3. How are the dead kept alive and commemorated?

End-users have the need to express grief in rituals, symbols, emotions and actions. Visible objects are worth a thousand words and are therefore an essential part of the funeral process.

A group of end-users wish to create a memory with a ritual, creating a memorable end of life experience.

The desire to design this experience the way the end-user wants to, like a 'do-it-yourself' funeral, is growing. This desire means their needs will change from being a participant and observer into being an organiser during the funeral process.

More responsibilities will fall on their shoulders because of the desire to shape and personalise the process how they want to. It is interesting for Loop Biotech as a provider and the product they sell to give the end-user the option to organise it themself. The vessel is an outfit that revolves around the delicate moment of death. It leads human beings into the next step in the cycle of life. The vessel can support in creating a unique ritual because an unforgettable event is memorable.

What rituals and symbols are desired from a coffin to help with grief?

- A coffin can help with the confrontation with the dead body.
- The closing ceremony can help take the next step in the grieving process.
- The coffin stands symbol during the funeral ritual—symbol of the union between earth and sky, body and soul of the deceased or a reflection of personality.
- This delicate moment at the end of ones life can reflect in a delicate design.

These are all valuable insights that are considered during the ideation phase of creating a do-it-yourself ritual.

2.6 The Providers

To answer the research questions in the best possible way to obtain the goal of the research, literature, interviews were analysed. The needs and desired experiences of the stakeholders were extensively examined. These insights were used to create the design direction. The research about the providers is elaborated on in this paragraph.

1. What are the needs of the providers?
2. How will their needs change over time?

2.6.1 Providers

When looking at the stakeholders involved concerning the providers, the meaning of a funeral is clear: it is the product they sell, the means to make money.

When discussing the funeral market in the paragraph 2.4, it was researched how the industry and the funeral process will develop.

The stakeholders in this market contain funeral directors and other funeral organisations such as coffin builders, coffin resellers, designers, funeral companies like undertakers, advisers, ritual guides and priests but even a florist, caterer, or funeral artist. Also, during funerals, chauffeurs are needed, a mortuary to store the body and a gravedigger.
Taking care of the deceased in its final stage also includes a doctor, caretaker and final caregiver.
And some parties don't have the means to make money but mainly inform, like the government.

2.6.2 Desktop research Providers

A farewell requires attention and intensity. Honoring and memories are central. However, the task of organising a funeral can be heavy in a state of grief. That is why the undertakers and other providers support dealing with dying, death and grief and the organisational aspects that come with it.

Especially during this process, comforts can be crucial. Palliative care has different aspects of comfort before, during and after death for the user group. Physical, psychological, social and spiritual care can be provided by different groups. One of the needs during grief is the establishment of social support and care. (Falconer, K., Sachsenweger, M., Gibson, K., & Norman, H., 2011). How is this support established?

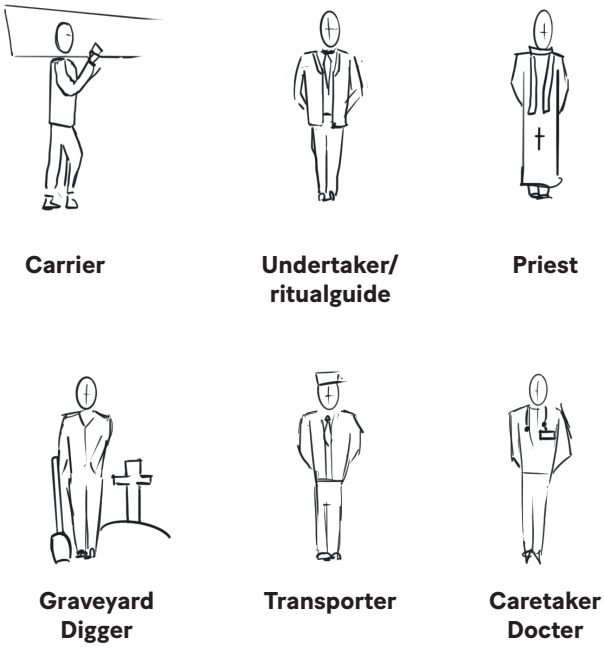


Figure 55. Example of providers



Figure 56. *Memorials: ash storage, urn, sculpture*

History
To understand how the role of the providers will change their history is researched. The modern funeral home emerged in the early 20th century and became the epicentre of the business of death. This funeral home contained a funeral parlour that resembled the living room of a personal home where the close bereaved could display the body, and the funeral rituals were presided over by the funeral director. (Harris, 2007). The business grew, and more interested 'providers' emerged, all wanting to be a part of the process and demanding the busines to change.

Funeral providers determined the market mainly due to the end customer's wishes and needs and the provider's motivation to earn money. The providers engaged in new marketing methods to attract business by offering a comprehensive and distinct array of services.

Present
These businesses are available due to changes in the funeral industry adopted by individual funeral homes or by the industry to further specific business-related goals. For example, funeral homes are now educating their customers or marketing to their customers by informing them that there is much more to cremation than simply cremating the body and returning the ashes to the family.
These services include off-site memorials:
- that incorporate the use of audio or video tributes to the deceased,
- the release of butterflies,
- a host of cremation-related merchandise such as urns,
- jewellery,
- sculptures, and other items made from the cremains or that are used to store the deceased's ashes,
- poetry readings,
- bar services, live bands (Campbell, 2002; Clark, 2012; Crabtree, 2010; Schneider, 2002).

Providers faced challenges in which they were either forced to innovate to bolster profits or meet the possibility of growing stagnant or even going out of business (Crabtree, 2010). As a result, the new approach offers a seemingly endless menu of tangibles or services available to the bereaved family.

Figure 57. *Natural burial*

Figure 58. *Support*

Natural burial
This excessive list of options resulted in an overwhelming process for some of the bereaved and deceased. Consumers must make too many choices. This overwhelming feeling with the consumers explains the start of another movement of simplicity presented by providers.

The popularity of natural burial reflects a desire to break away from constraints of modern life (Claydon) free of excessive consumption and technology, to get in touch with the natural rhythms of life and death. (Walter)
Natural burial sites simplify the process.
In some cases, no official undertakers are involved, and the families and friends arrange things as they wish and therefore have a more intimate ceremony. Providers are only present to support and guide but step more into the background of the ritual.

It offers a context for memorialising a particular individual and provides a sense of ownership and control over one specific grave (Rugg, Defining the place of burial.)
Regulations at the natural burial ground only allow objects made out of natural, perishable or biodegradable materials. Deceased find comfort in the idea of returning to nature, not making a mark but joining the cycle of life.
Paragraph 2.6.3 elaborates on this topic.

Support
Though it may sound like this endless menu of tangibles or services are mainly money-driven, spiritual support, rituals, or symbols can provide a way of dealing with death and thereby asks for providers to support.

Providers introduce rituals and objects the family and friends can interact with.
For example through touch. Touching is being in physical contact, which is the basis for the feeling of being in contact. Within this contact, touch is a strong basis for developing feelings of intimacy on a physical and spiritual level (Fields 2003, Montagu, 1971). It is necessary for mental development and processing the grief of a loved one.

Figure 61. Natural burial site

Figure 59. Intimate ceremony

Figure 62. Biodegradable coffin

Figure 60. Biodegradable attributes

2.6.3 Natural burial

Natural burial is the most logical choice for the current living coffin. Cremating the mycelium casket will lose its purpose. Natural burial fits the idea of going back to nature, enriching the environment and a do-it-yourself funeral. This is why natural burial is researched in this paragraph.

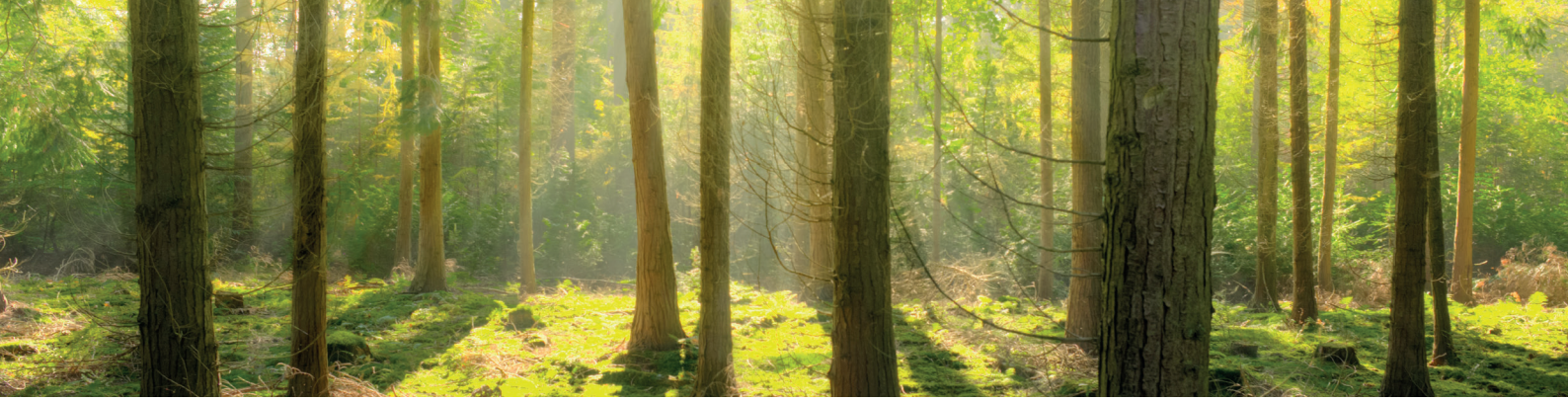
- Interviews with staff and management provided information about the people that were buried at Bergerbos, a natural cemetery in Limburg. The people interested in burial at Bergerbos were described by the staff and management as not truly 'green'. Instead, people with love for nature. This group desired a more ecological alternative to traditional forms of disposal but loved nature above all. (Mirjam Klaassens, Peter Groote, 2010)

- They indicated that the level of education of those interested was a decisive factor for choosing Bergerbos. In particular, the middle-class was interested in natural burial ground Bergerbos, whereas the lower social classes were thought to be less interested. When interested, the experience was that this latter group visited the graves more frequently and memorialized the deceased with objects less appropriate for Bergerbos. Furthermore, age seemed to matter greatly. The mean age of the deceased at Bergerbos lies around 53 years which is low. (Mirjam Klaassens, Peter Groote, 2010)

- The freedom at natural burial is in line with changing ideals, values and shifts in attitudes towards death. People, who are dissatisfied with the usual burial options, opt for ceremonies of their own choice by way of 'do-it-yourself' funerals. (Enkelaar)

- Only biodegradable materialized memorialization is allowed but keeping the children's graves 'natural' was a challenge. For the allocation of space a few deceased children in the centre of the burial ground, the exception is made. A marker in the form of a metal butterfly sets the area apart. It is a symbol known to a broad audience in the Netherlands for the beauty, fragile nature and transitoriness of butterflies that symbolize the death of a child (Mirjam Klaassens, Peter Groote, 2010). At regular cemeteries, it seemed that parents have a pressing need to be active at the grave, bring or do something, redo and rearrange, and express an ongoing sense of loss that characterizes parental grief.

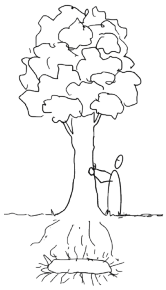
Insights
The end-user group who buys a Loop Cocoon are compared to the people who choose natural burial.
They are relatively young and dissatisfied with the usual burial. They desire a custom-designed burial. Children are excluded from this group



2.6.4 Interview providers

In addition to the literature research, experts in the funeral fields are interviewed. Semi-structured interviews of approximately 45 minutes give insight into the different domains of burial. Their needs, knowledge, experiences and expectations for the future are discussed.

- I see the industry changing in two categories. First, the industry is becoming more sustainable. And secondly, it is becoming more personal. (Interview Mijndert Rebel)



- I think sustainability will weigh much more heavily in the choices that are made. Biodegradable products, for example. And that it gets a more personal touch, so a kind of custom industry. At some point, all the old "religious" and more "traditional" ways of burial will transform in a way. And the next generation will therefore also have other needs. (interview Anneloes Kokshoorn)

- In Britain, it is common to turn the deceased into a tree, which can be touched and gives the feeling of connection (interview Anneloes Kokshoorn)

- You don't have to look after the grave or take care of it. Mother nature will take on this job. But you can if you want to, taking care of a grave is an expression of their grief. But with a natural cemetery, this only can be done with biodegradable products. (interview Marc Hesp)

- By becoming a tangible part of nature, you can show what you stand for and enable proper closure for your loved ones (interview ritueelbegeleider Zilla van Dijk)

- People want to be buried because they want to continue their presence on earth (interview Zilla van Dijk)

- My main goal as an undertaker is unburdening the client and making sure they get what they want. (Interview Mijndert Rebel)

- Sustainability is becoming an essential factor. The deceased wanted to make a final statement, even after their death, by showing appreciation to earth (interview Anneloes Kokshoorn)

- Funerals can be very polluting. The gravestone will be flown all over the world to get engraved, polished etc. Coffins are also often made of unsustainable materials. We must improve this. (Interview Marc Heesp)

- As the years passed, I attended several

funerals; I noticed how many farewell services in the Netherlands resemble each other. While the unique funerals are so beautiful, they stay with you. Often these are funerals where the relatives were in control and who dared to think outside the box. That is how I knew I wanted to be an undertaker and try to make every farewell personal and beautiful. (Undertaker Susanne Duijvenstein)

2.6.5 Conclusion Providers

To answer the research questions
1. What are the needs of the providers?
2. How will their needs change over time?

So, in conclusion, over the last years, the funeral industry demanded change, and the providers engaged in new marketing methods by offering an endless list of products and services.

This growing market resulted in the provider's needs moving in two directions.
1. In some cases, the provider will have to step into the background and have a more supporting function. They require a operating field to do so. The natural burial trend meets these requirements and needs and offers opportunities.
2. Providers presenting the consumer product and service options that are expected to become sustainable and biodegradable. Since they don't want to overkill the consumer, simplicity and back-to-nature will become more popular styles to offer.

Both changes are interesting for Loop-Biotech as a provider and the product they sell.

The first change stimulates the popularity of natural burial. Natural burial sites offer environmentally friendly funerals in a natural landscape.
This opportunity can be used as substantiation for the design of the redesign.

The second change allows Loop Biotech to adjust the product and provide a unique styled funeral product. As mentioned above natural burial requires a new range of biodegradable funeral products and the need to express nature in a simplified format. This will give opportunities to distinguish Loop from other coffin-sellers.

2.7 Overview Research

This paragraph gives a complete overview of the results and insights from chapter 2. These results will be used in formulating the design challenge in chapter 3 and during the design process.

The assignment of the project is to redesign the *mycelium coffin* to reflect and communicate the contribution to *the cycle of life* through *aesthetics* and create an *experience* to support the *funeral ritual*.

The research will be used as input to realise this assignment. As guidance to understand what the needs of the users are, for the development of mycelium or fungi-based products and growing in the funeral industry, the main research question is as follows:

How can a mycelium funeral vessel be designed on a technical and experiential level to support and optimise its meaningful value in the funeral industry?

Dividing this question in five paragraphs; the company, the material, the market, the end users and the providers helped answer this research question.

It is good to mention, the student interpreted these insights due to personal taste and style. Her preference for changing the shape is because of the passion for minimalism, organic and nature, simplicity and less is more.

The personal ambition is to design a vessel that stands out, is unique in the industry and creates a new experience for the consumer. Additionally, a hands-on project with much tinkering, building prototypes and using creativity in the design process, the ambition to improve arose.

In this way, a memorable moment can be created, Loop can benefit from the product improvement, and most importantly, the graduation project is fun!

Figure 63. Student tinkering

Company
The general conclusion that the research can draw from the company analysis is that the living coffin has the potential to become a truly valuable product for the bereaved. Nevertheless, the product does not emphasise the actual inviting, growing and demolishing nature of the material in its production.

Additionally, the coffin is perceived as a coffin and strives to look like one. The rectangle shape causes a pessimistic product experience beforehand and causes product failure during the process. Distinguising itself from the coffin catergory (and move to the 'body in shrouds'-catergory) provides the opportunity to improve the product performance and perception.

Material
With fungi based material, it is possible to see and feel the material, which emphasises the naturalness and 'living' characteristics of the material.
In existing mycelium products, the basic instinct of the material (to demolish) is suppressed, and products are shaped in basic shapes and forms.

Market
The funeral industry is changing and teaches us that it will move in four directions. Personalisation of mortuary rituals, increasing environmental awareness, high-quality services and death becoming a more accessible topic to talk about.

The end users
The end users are expected to follow the trends the funeral industry provides. They feel the need to create a custom-designed burial and connecting with nature when life comes to an end is growing. These trends are interesting for Loop Biotech.
Firstly, the growing popularity increases the quest for biodegradable coffins.
Secondly, it gives the opportunity to expand their product line with a new range of biodegradable funeral products.

The deceased sometimes feels the urge to make an environmental awareness statement and share a message with their goodbye. They experience the desire to transform from death into nature. They are questing for biodegradability and eco-conscious products and rekindle the connection with the environment.

End users express grief in rituals, symbols, emotions and actions. They feel the need to mourn the death of someone, come together, perform a ritual and create a meditative experience that intends to help with emotional healing. The desire to design these rituals and symbols by themself to create a personal and intimate ceremony is growing. Thereby creating a memorable moment through a greener burial ritual.

The providers
Because of this, the providers' needs will change. In some cases, the provider will have to step into the background and have a more supporting function. They require a operating field to do so. The natural burial trend meets these requirements and needs and offers opportunities.
Providers want to present the consumer product and service options that are sustainable and biodegradable. Since they don't want to overkill the consumer, simplicity and back-to-nature will become more popular styles to offer.

3. Design direction

3. Design direction

In this chapter, a design direction is formulated. This design direction is the result of the insights in the research and the personal interpretation and preference of the student. This chapter is the starting point for the ideation phase. It narrows down the initial scope.

3.1 Design goal

3.1.1 Design challenge

With the improvement of design elements, this project will showcase an experience supporting and enriching the funeral process experience using aesthetics and rituals.

The challenge is to create a different product perception. Right now the coffin is catagorised in a coffin section. The challenge is to place it between a coffin and body shrouds category. The ambition for the redesign is to distance the consumer's perception from a coffin and stimulate perception as a vessel for the body.

3.1.2 Design direction

"Design a funeral ***vessel*** that includes an optimised ***mould*** system for sustainable ***production*** and product-***use***, while creating a ***memorable*** moment when life comes to an end".

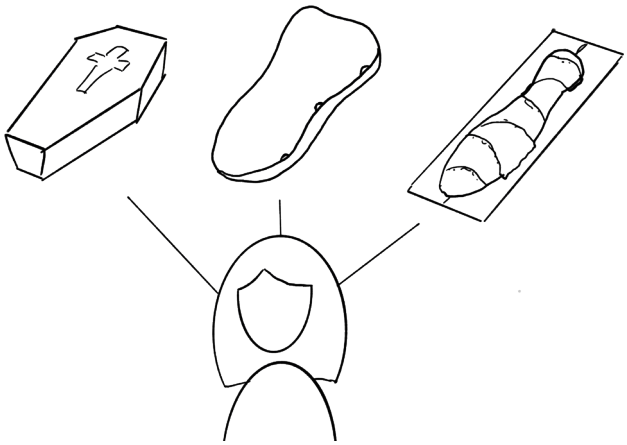


Figure Different product perception

3.2 List of requirements and wishes

For the full version of the list of requirements of and wishes see the appendix.

Functionality	Measurements	Material	Production	Mould
Use				
A design that supports tasks and providers and users executing it	width and depth that fits the curves of the body	Optimal mycelium quality	Producable	save and easy to clean
clearly communicate its function and possibilities		basic instinct of the mycelium		
efficiently transported				
not be damaged				
Water resistant exterior				
Lid				
handable and liftable by maximum 2 persons				
prevents looking inside				
the ritual of closing the coffin				
Bottom				
accessible from two sides				

4. Ideation

4. Ideation

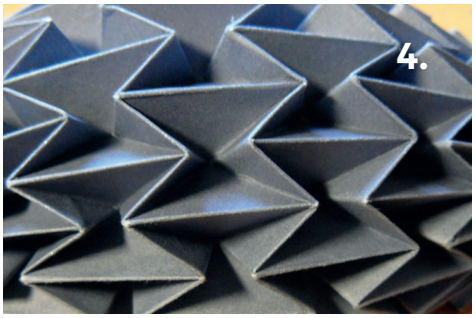
The diverging phase, described in this chapter, shows the search for a design that fits the design direction. It investigates possibilities that are used later on during the concept design phase. Methods are selected, and the required physics are investigated.

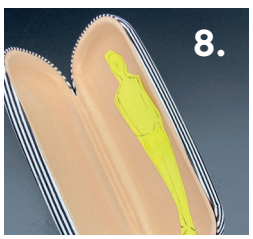
The process starts with looking for inspiration.
1. Collages visualise the vision and the meaning of the product.
2. Next, a brainstorming session with Loop colleagues provides insight into design opportunities and feedback on ideas.
3. A form study shapes the ideas. First creating sketches, and next making speedform models, and clay models make the ideas tangible and trigger reactions.
4. Researching use cues provide the end consumer with a trustworthy product that will not trigger any hesitance about the functionality and product performance.
5. Next to that, prototypes with mycelium test the structure and production process for the concept design.

4.1 Inspiration

Designing and ideating starts with inspirations. Inspiration can be found in everyday objects, images on social media and storytelling. With the help of collaging, ideas are generated. The examples below visualise inspirations for this project.

1. Found on the street: the inside honeycomb cardboard structure of a door.
2. Discovered on Pinterest: In-mould growth.
3. During shopping in the Action: 3D cardboard puzzle.
4. Origami structures of Carla Feijen.
5. The microscopic level of mycelium.
6. Found during a walk in the forest: the organic shapes of mushrooms in the wild.
7. The plates inside the head of a mushroom.
8. Found in the Action; glass case as a mini coffin.





4.2 Vision

Insights from the research showed that the deceased sometimes feel the urge to spread a message with their funeral ritual. Below is analyses what is meant.

Collages

Making collages visualised four different visions. These are all personal interpretations of the end of life and the message that could be spread.

Collage #1 Letting your thoughts breathe

This collage visualises grief. Dealing with the loss of a loved one can be challenging. Grief and sadness are dealt with in different ways because it is different for every person.Sadness is something abstract. It is a moving emotion, organic and living inside the brain. By letting it breathe (lungs are metaphor), sending oxygen to the mind, one can process these emotions. Thinking about the grief and loss one can help commemorate. The lungs below send oxygen to the mind. The mind is organic thoughts and visualise how one could process grief.

Collage #2 Spreading a message

This collage tells the story of the journey one will make when one has passed away.
It will continue a journey through nature, using a vessel to guide and support. In this case, a boat floating over the river, going to its next destination.
The vessel will tell something about that person and spread a message, even when out of sight. The flower seeds will spread with the wind and continue to live and grow elsewhere.

Collage #3 Giving back to nature

When buried, nature will include your body. With a vessel, your body will enrich nature and provide nutrients for soil and trees to grow. You will still be present on this earth, in the trees, the air and everything around.

Collage #4 Providing air for the next of heir

Trees are called the lungs of the earth. But it is the roots that make the trees live.The roots are the lungs. The boat stands for the coffin, a vessel sailing towards nature. There it will produce oxygen for the next of kin, the young girl on the left will be able to live and breathe because of the mycelium vessel.

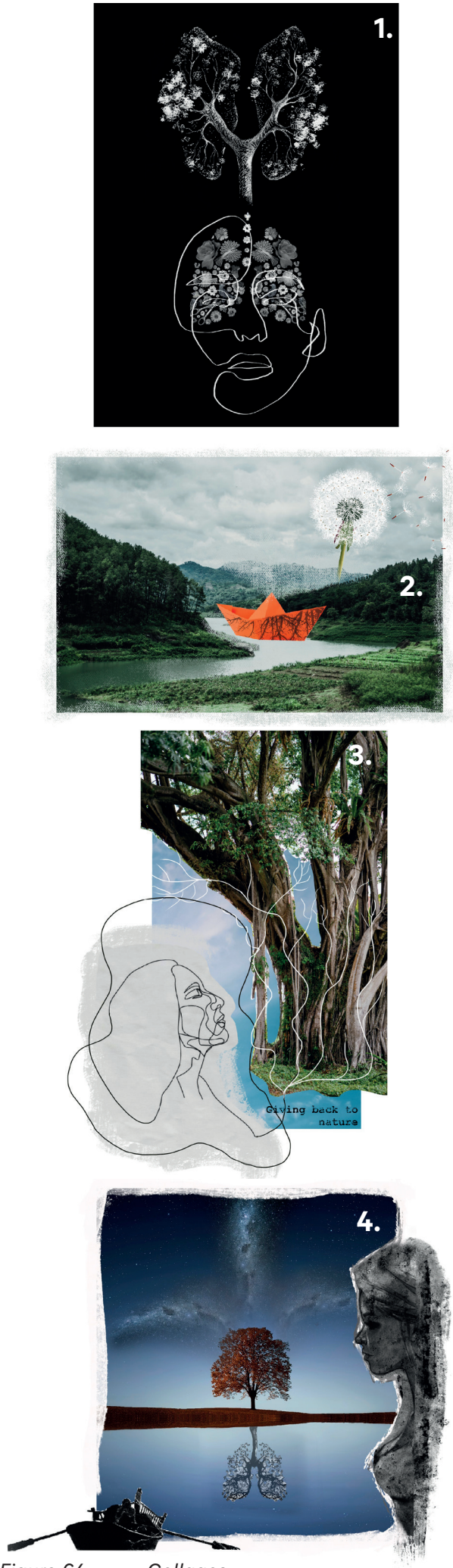


Figure 64. Collages

4.4 Form and shapes

This paragraph shows an analysis of forms and shapes. This analysis creates concepts that will be developed and tested in the following chapters. Defining the general shape and structure of the final product, was the fourth step during the ideation phase. The main goal of the shapes is to narrow down the design direction and to create a solid base for generating ideas. Quick 3D view sketches were made to explore different directions (see figure 73; other sketches can be found in appendix I). The sketches were then evaluated with the following set of 4 criteria:

- The shape must limit a coffin consumer perception.
- The shape must emphasize the material and the ability to create organic shapes
- The vessel must provide a barrier between the deceased and the close bereaved:
    - o Light coming from above
    - o Light coming from 2 sides
    - o Sightlines from others (side view)
- The vessel must have relatively simple shapes for production purposes.

Sketches illustrate a brain dump of all ideas that came to mind.

- Ideation on the current coffin shape
- Ideation on random objects and shaping them into a coffin
- Improving framework
- Having the ability to take a sample piece of mycelium home

Based on the selected sketches, shapes were found to fit within the criteria and have the potential to become a realistic product.

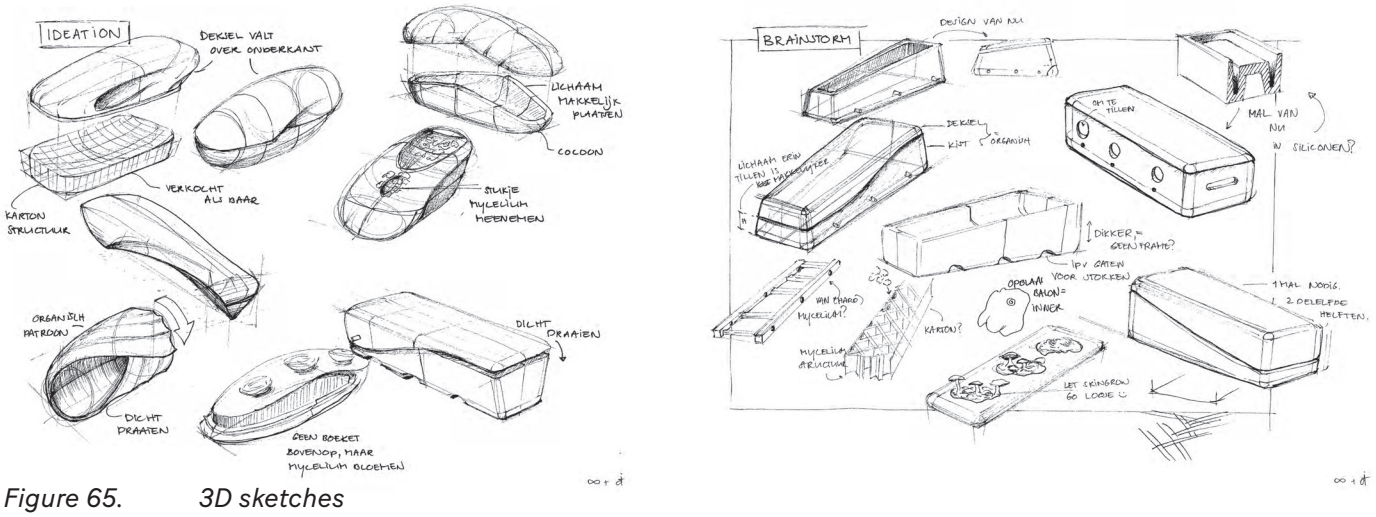


Figure 65. 3D sketches

4.5 Speedform study

The speedform-study shaped the most promising sketches into foam and clay.
The form and shape are fascinating since this expresses something about the design. The various speedform sculptures, displayed below, created the base for the concepts in Chapter 5.

Foam Models

Studying shapes and bringing them down to their simpler forms, and giving them personalities brings out sculptural beauty.

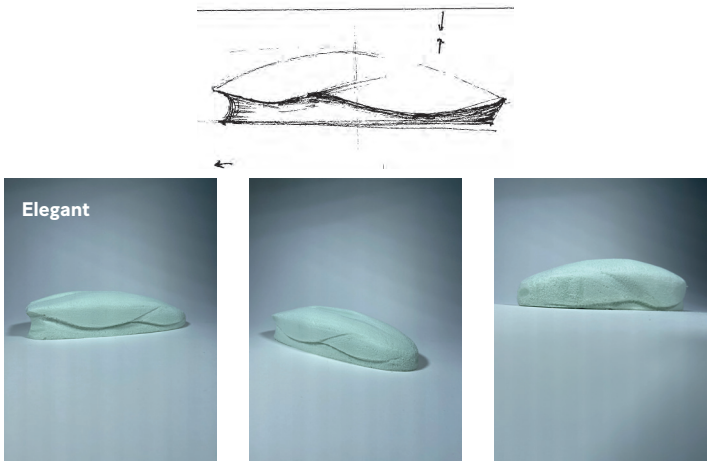


Figure 66. *Foam model 'Elegant'*

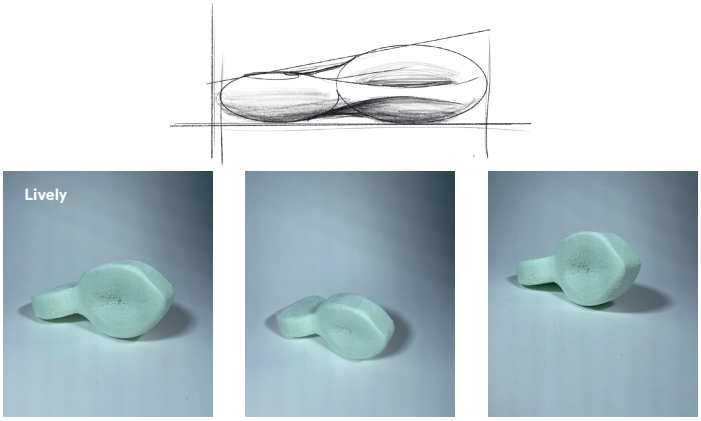


Figure 67. *Foam model 'Lively'*

Insights

These shapes show the different forms a coffin can take. Derived from the research in chapter 2, the desire is to have an organic and natural shape. The coffin is alive due to its material but is experienced as dead by consumers.

Shape #1 shows elegance but also practical insights. The lid is the heavy part, and the bottom being the part that carries most of the body weight.

Participants described shape #5 as lively. If looking from above, the shape shows similarities with an infinity sign, which appears in the logo of Loop.

On these two shapes, an iteration was done with clay.

Clay models

A shape like the current coffin is often compared to a fridge.
The shape of the redesign must prevent this. That is why a test with clay models was done. Fellow students were asked if they noticed comparisons to unrelatable objects. So the question was asked; what does the shape remind you of?

Outcomes:
-Seashells
- Cookies
- A mars or a twix
- A baguette
- Coral
- Paprika
- Ginger
- Carrot
- Poop
- Salmon piece
- Space ship
- Stabilo Pencil
- Potatoe
- Peanut

Insights
The students made a lot of comparisons with food.
They all thought the shapes were unique compared to any ordinary coffin.
All comparisons were natural objects with organic shapes.

Discussion
The test outcomes are influenced by the size and colour of the clay models. If the objects would have larger dimensions, these comparisons would probably be different.

Figure 68. Clay models

Mycelium prototyping

Tests with cardboard frameworks provide insight into mycelium performance and structure.

A 3D cardboard filled with mycelium will allow production with an in-mould instead of an outer-mould like the current coffin production.

Insights
Prototype #1: honeycomb cardboard filled with mycelium. The paper structure improves the overall stiffness of the material. This model proved the honeycomb frame to work. A stiff prototype was the end result, which provided the opportunity to become the basis for an innovative production technique.

Prototype #2: a 3D cardboard puzzle for children filled with mycelium. Mycelium fibres will fall through and needed tape to press the fibres in place. This prototype provided the knowledge there should be a mould/obstacle to prevent the fibres from falling out the structure.

Prototype #3 is a scale model of a cylindrical construction. Once filled with mycelium composite, the moisture made the construction collapse. The cardboard tore apart, and this prototype failed. This prototype proved the level of moisture in the mycelium is to be crucial. Too much moisture will rip the paper.

Prototype #4 is an egg box made of paper mache. This prototype showed the mycelium would eat its way through this material while still having the initial structure. The following prototypes could use a comparable biodegradable material to prevent the mycelium from 'falling through' like the tape obstacle did with prototype #2.

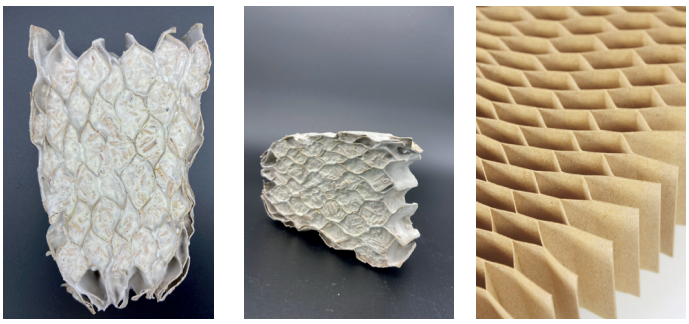


Figure 69. *#1 Honeycomb cardboard*

Figure 70. *#2 3D cardboard puzzle*

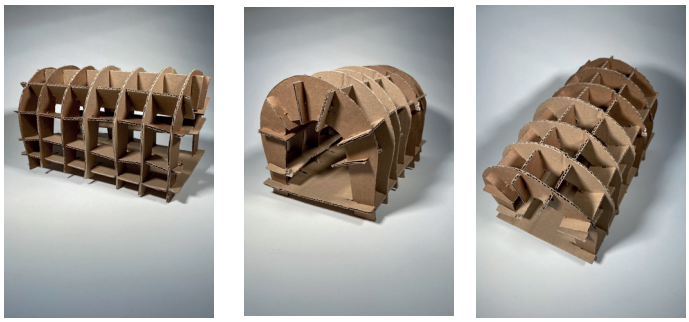


Figure 71. *#3 Cylindrical cardboard frame*

Figure 72. *#4 Eggbox paper mache*

Use cues

The vessel should communicate its function and possibilities without raising any doubts or hesitates when interacting and performing tasks.

When collecting feedback, consumers raised questions about

- How to lift the coffin
- The lid blowing away
- Transport the coffin
- The material

Researching use-cues provide the end consumer with a trustworthy product that will not trigger any hesitance about the functionality and product performance.
A collage is visualised with clear use-cues in other design projects.

Insights
A hand-shape cavity can guide the user automatically to a handgrip.
The material must externalise confidence about its weight

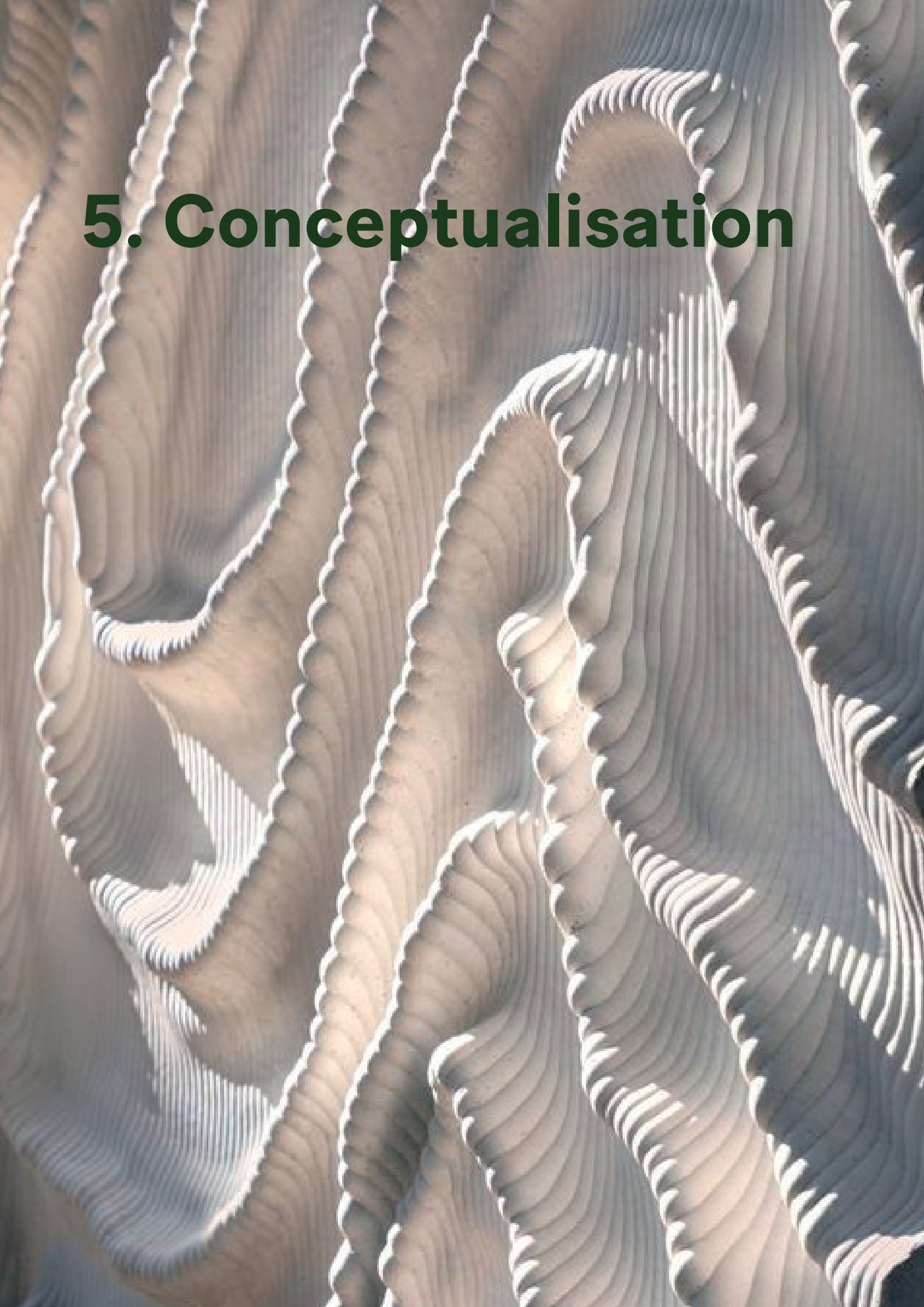
Figure 73. *Collage Use-Cues cavity*

Decision-making process

All the requirements and wishes eliminate ideas that do not meet these demands.
This resulted in three concepts that will be visualised in the following chapter.

For the full decision making process see the appendix.

5. Conceptualisation



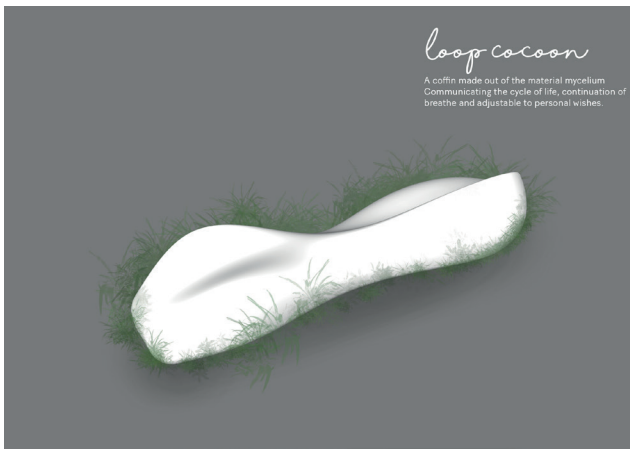


Figure 74. *Concept #1 The Human body*

Figure 75. *Concept #2 Breathing*

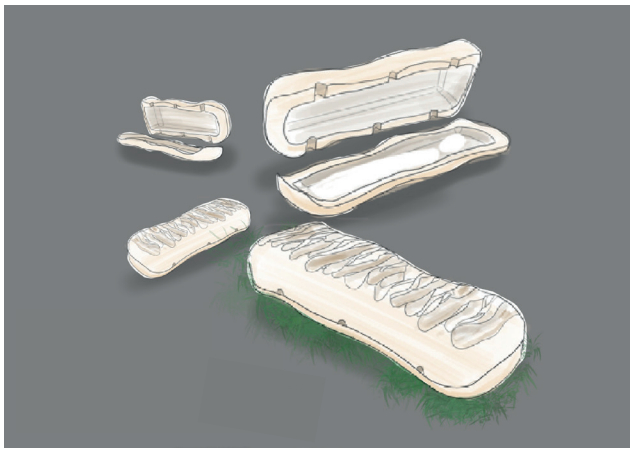


Figure 76. *Concept #3 The Root Network*

5. Conceptualisation

For the concept design phase, different elements are worked out apart from each other.
1. The Shape
2. The Interaction
3. The Production

5.1 Concept shape design

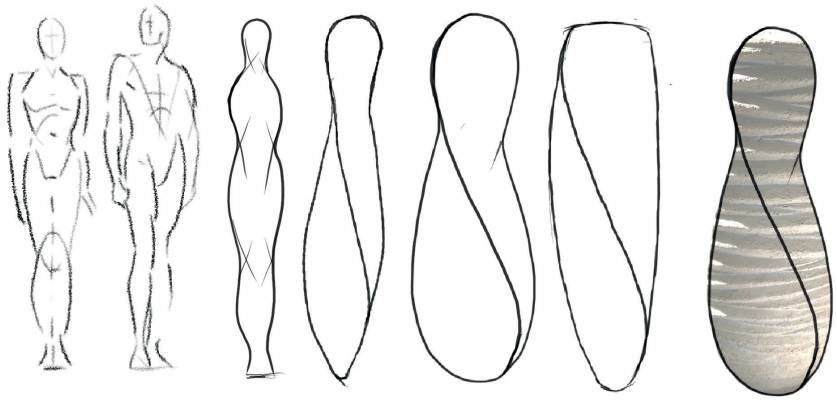
Together with the Loop-team, the concept choices are based on the externalisation of the shape. During a brainstorming session, the most promising forms were hand-picked. Externalising is showing or expressing something on the outside of a product.

Three concept designs follow that are developed equally. On the following pages, the design process of the three concepts is visualised.

Concept #1 Body
The inspiration for this shape comes from the body-shape of women and men.
Redrawing the shape turns the body into a casing for the body with organic curves.
The infinity logo of Loop is integrated into the 'figure eight'-shaped design.

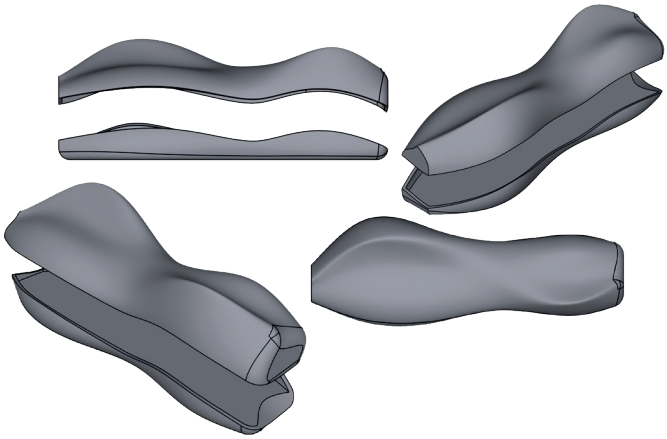
This asymmetry externalises the natural shape of the body. Without any static corner or surface, this concept fits in a natural surrounding.

1. Shape inspiration
Human body



3. Context drawing

2. Shape put into 3D



Concept #2 Breathing

The second concept shape is unique due to its particular surface structure.
The flowing structure reflects the waves of breathing.

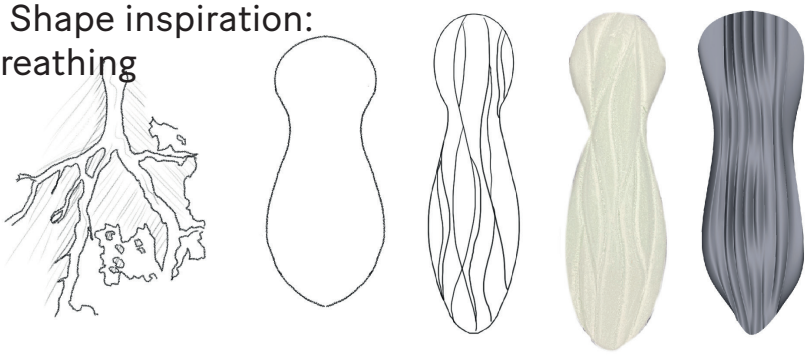
Life is a complex deep journey through time and space that flows like air. The breathing pattern one has can be seen as a metaphor for how one lives. Because changing the way of breathing affects the physical and mental condition. And because breathing and thoughts are congruent, breathing affects the thought patterns and vice versa.

We currently live in a fast-paced and demanding society. One of the consequences of this is that we hold our breath regularly. We keep our breath in not to feel what is unpleasant. We then deactivate our emotions by literally holding them in, which requires a lot of energy and creates chronic tension in our body.

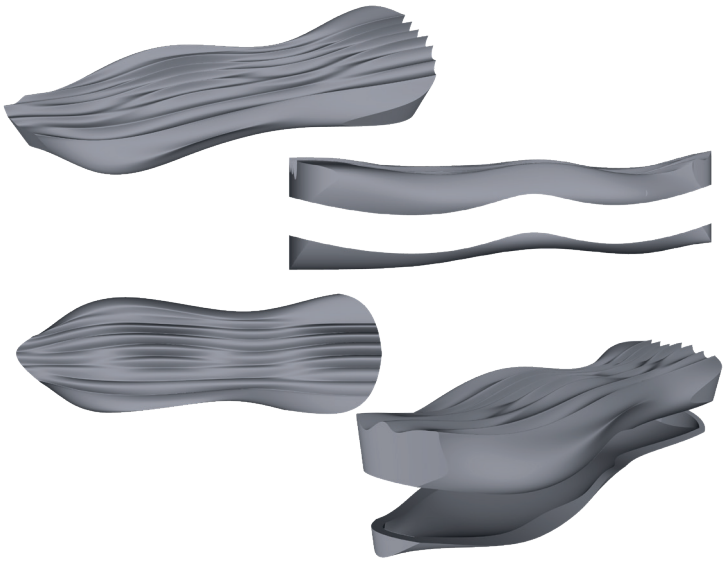
The unconscious tightening of muscles as a result of stress or trapped emotions, for example, during a funeral, causes limited breathing. Both ultimately have disastrous consequences.

The breathy pattern stimulates breathing and supports the emotional rollercoaster during a funeral ritual. It makes the shape look alive and moving, externalising the livingness of the coffin. And how the deceased will continue to live on via its vessel. The vessel will breathe for the deceased, figuratively in the breathy pattern and literally through the material.

1. Shape inspiration: Breathing



2. Shape put into 3D



3. Context drawing

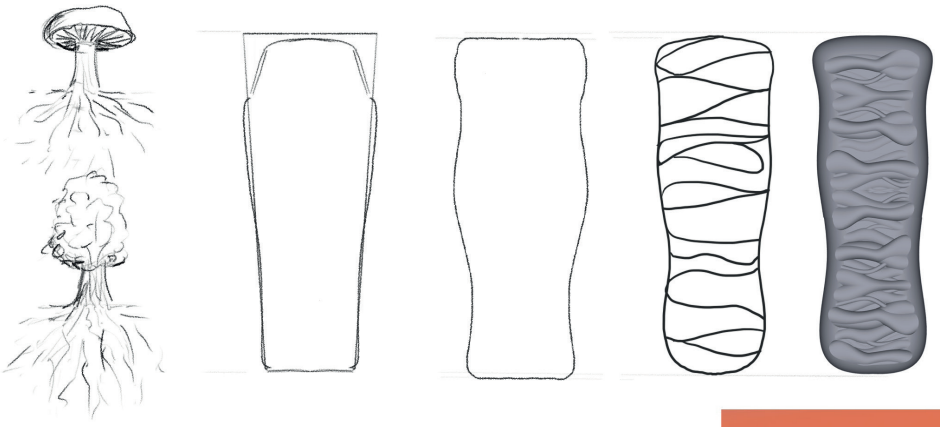
Concept #3 Root network
This shape is more square-shaped and stays close to the original coffin design.

Loop-biotech is still doubtful whether to make minor adjustments to the current coffin design instead of changing the complete shape. This concept is a redesign of the current coffin with minor adjustments realisable for Loop.

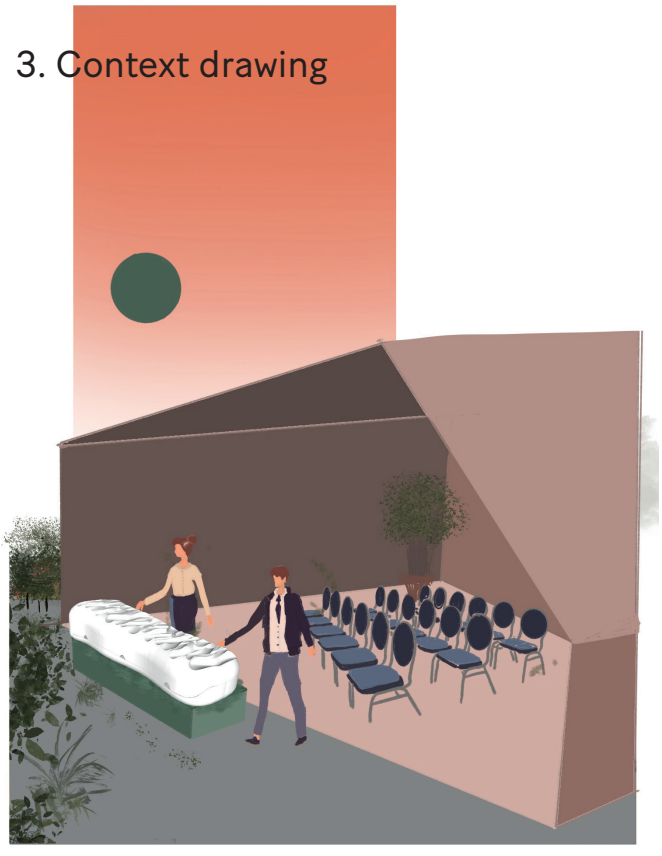
Trees and mushrooms grow individually above ground while sustained by a common network of roots underground. They will continue to grow and live elsewhere once they have died.

This story is a metaphor for the cycle of life and what will happen to the deceased. The material is the primary driver of this story, but by adding a structure externalising the root network of trees and mushrooms, the message is communicated more clearly.

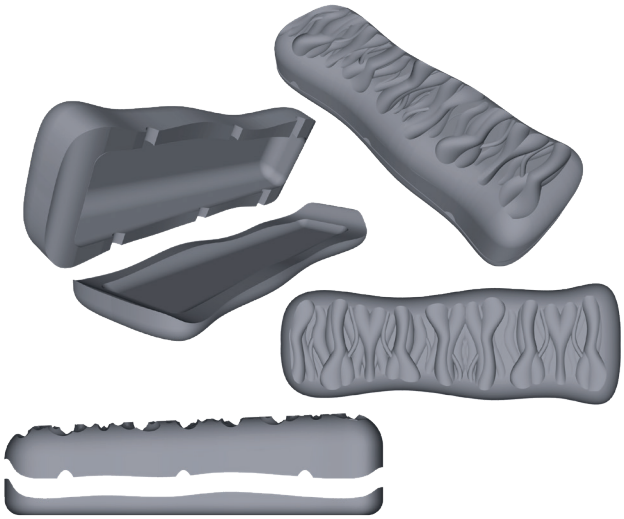
1. Shape inspiration:
Root network



3. Context drawing



2. Shape put into 3D



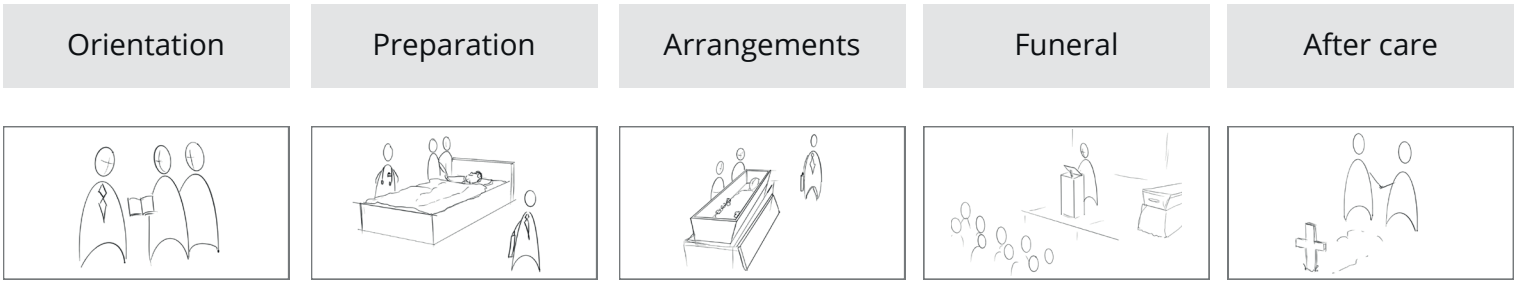


Figure 77. Method 1, timeline

5.2 Interaction

The consumer-product interactions desire to create a positive effect level.
The effect level means two things:

1. What you want the user to do, experience, feel, and how you want your user to behave during the funeral process.
2. And secondly, what effect is relevant to the user's ritual.

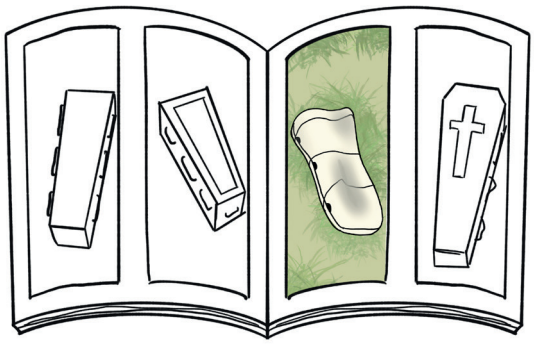
The first method is empathising with the vessel. The question is asked: What if the vessel is a person? A timeline visualises what the vessel must feel and wants to express at moments in the delicate process (see appendix P for elaborative version)

The second method is a similar timeline. This visualises the timeline of moments of interaction with users and the vessel during the funeral process from method one. These moments are used to ideate on defining the desired interactions for the concepts.

Orientation

Selecting the coffin:
The user selects a funeral coffin through visuals in a catalogue. The end-user often experiences many emotions when establishing this.

The Loop vessel will stand out compared to the other coffins due to its unique shape, colour, and story. The end-user will feel special and relieved that there is a product that fits their ideology. Likewise, the providers will feel unique they can deliver a high-quality product.

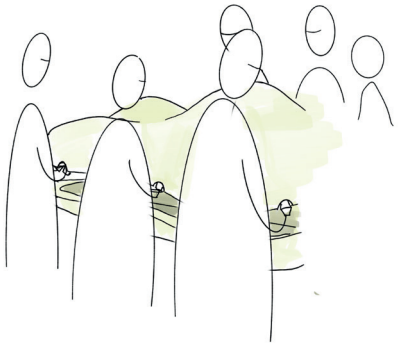


Preparation

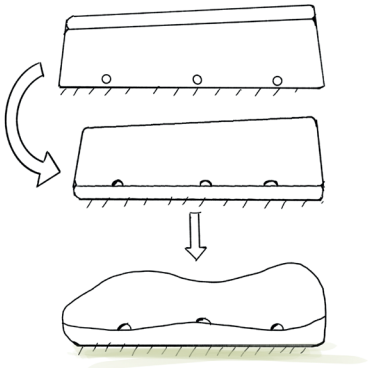
Confident product performance:
The providers feel confident the vessel will perform like it has to. The product expresses the securing feeling it will transport smoothly, hold the body, fit the body dimensions, prevent it from leaking, and support the ritual. The vessel meets all the functional requirements.

Arrangements

Closing the lid:
One of the most striking effects of a ritual is the group's social cohesion carrying out the closing ceremony. With the lid closing, multiple carriers must delicately contribute to the act, creating union and social support. It will be the last time the group will physically see the body. Providing the option for a lid-closing ceremony will allow the close bereaved to create a memory and say farewell.

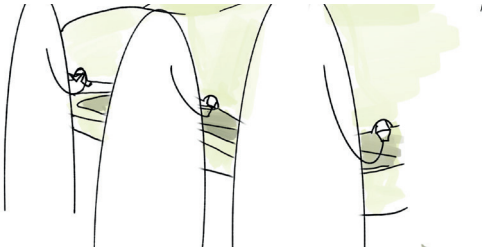


The upside-down design:
By flipping the current coffin design 180 degrees and making -the lid the bottom and -the bottom the lid, a problem is solved. The issue of -a feeling that the lid might blow away- is no longer present when users encounter the vessel for the first time. The lid's weight makes sure the lid will stay in place. It provides the secure feeling that there is no hesitation about



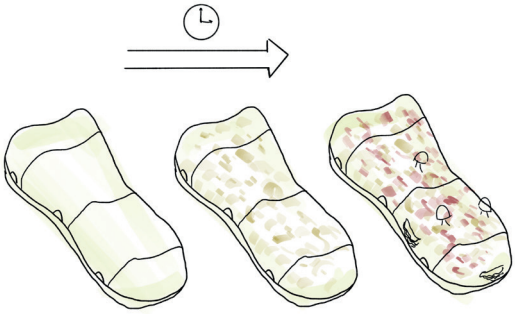
Use-cues

With use-cues in the lid, there will be no insecurity present, and the user will behave and interact confidently, executing the tasks. They will know what to do due to the use-cues that steer them in the right direction.



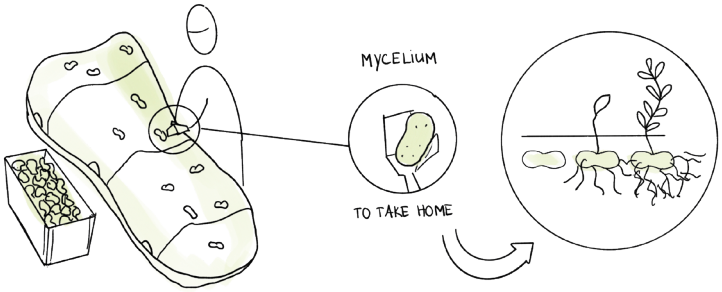
Funeral

Unique aesthetical elements:
The lid can be grown in different ways. Users can choose to continue the skin growth process for the number of days of personal preference. This number depends on how 'natural' the aesthetics wish to be. The longer it grows, the more natural it will appear. By looking at the vessel during the funeral, people will recognise the person lying in it through the level of naturalness of the aesthetics and, therefore, uniqueness. Visitors and close bereaved see the level of naturalness as a reflection of the life that is commemorated.



Aftercare

Mycelium samples:
Samples will provide a tangible object in which memories can be stored.
-To remember the funeral process
-To remind the person
-To continue the message that is spread
-Branding for Loop



5.4 Concept choice

For further technical details about the concept choice see appendix L and M.
The preference was given for the organic body shape.

6. Embodiment

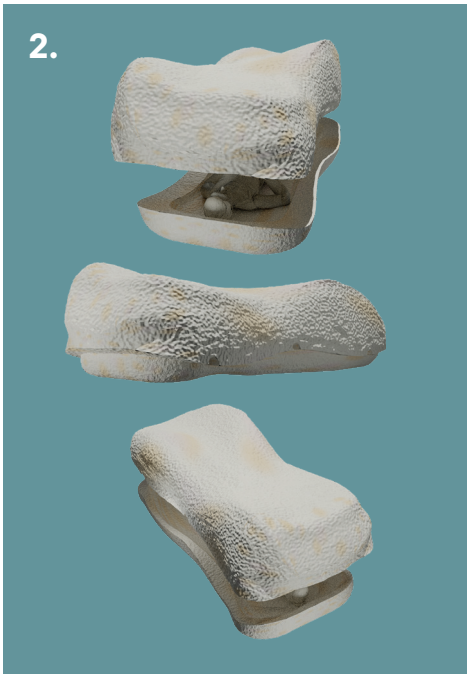
Prototype

For de prototypes and further product development see the appendix.

Iteration shape

The design of the Loop Cocoon includes ‘wrapping‘ the body in natural mycelium spores.

Four product concepts were generated and discussed according to their shape and human body reflection. The abstract lines and folds in the surface cause the product to be perceived as a human vessel. The body inside the vessel is placed on a wood base and is held and supported by an interwoven structure of mycelium spores.



The final design

The Loop Cocoon

To allow the transformation from death into new life, restore a connection with nature and create a memorable moment when life comes to an end.


The Loop Cocoon

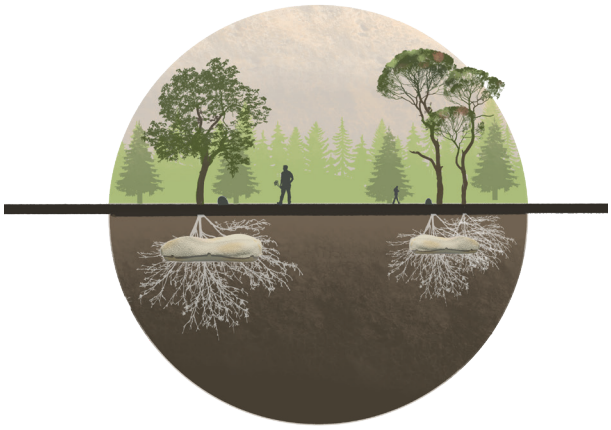


Figure 78. *Cycle of life*

Figure 79. *Closing ritual*

Cycle of life

Our traditional burial methods when life does come to an end are harmful to nature.
The material mycelium will enrich nature instead of polluting it. After burying the deceased, the fungi will grow and speed up the body's natural decay. At the same time, the mycelium digests and dissolves any toxins in the body, only permitting nutrients such as oxygen and nitrogen to access the soil.

Once the soil is healthy and full of nutrients, the bereaved can plant a tree above the burial site. This tree symbolizes a beacon of new life, a memory or an ode to nature. The three can be a physical memorial and a place to visit once in a while.
The Cocoon allows the transformation from death into new life and revitalizes the connection with nature.

Ritual

Sealing the Cocoon creates a ritual that helps those who mourn the passing of someone. They come together to close the Cocoon, a meditative experience that intends to help with emotional healing. The family and friends can lift the top part with six people. After the body is carried onto the bottom, the top closes the Cocoon. This interaction with the product and feeling the material can support people with their grief and create a memorable moment when life comes to an end.

Figure 80. *Final design*

7. Recommendations and discussion

7. Recommendations and discussion

7.1 Recommendations

These recommendations can be used as future steps to develop the Cocoon into a fully functional product.

7.1.1 Aesthetics

The design should evoke support and interaction with the deceased.
The shape is based on the personal preference of myself, the Loop team and students outside the team. Due to the coronavirus, a small number of reviews and opinions were gathered to get feedback on the shape. It is advised to collect feedback from a wider audience, such as consumers like potential buyers and undertakers.

7.1.2 Samples

In appendix K an idea concerning mycelium samples is visualised. This idea provides the opportunity to interact with the material and create a ritual.
The deceased is commemorated. A message about environmental awareness is spread. When buried, the environment at another place than the grave is enriched. Furthermore, the sample piece can be branding for Loop Biotech.

Nevertheless, it has not yet been proven that the mycelium will visible grow when one buries a piece in their garden. It will enrich nature below ground, but this will not be visible above ground. The interaction with the sample provides the opportunity to take care of a plant or tree that will grow on the piece of mycelium. However, it is questionable whether this will happen.

7.1.3 Functional development

Recommendations concerning the functionality of the Loop Cocoon are mainly based on the prototype. Material properties need to be explored and tested further to collect knowledge about the technical performance of the cardboard structure.

Scale
It is recommended to build a 1:1 model of the Cocoon to test the product performance. Concerning dimension, shrinkage, carrying the bodyweight and testing the production method.

Weight
The prototype and unlying support board has not been tested to carry weight.

7.1.4 Sustainable

Cardboard is not a material that enriches the environment like mycelium does.
It is strongly advised to search for alternative materials with higher biodegradability and sustainability.

Another option is to design a mycelium based framework.
Fibres in a composite improve the mycelium composite quality. During the tinkering phase in the MDD method, coconut fibres were tested as an alternative. Because of the 'hairy' coconut shells, colonisation of the mycelium network was exceptional. Nevertheless, coconut fibres decompose slower compared to hemp fibres. It could be interesting to make a coconut fibre inner framework and still use hemp fibres as base material.

7.1.5 Assembly process

Loop strives on producing coffins worldwide. They have the ambition to ship a mould plus mycelium composite to another country where the coffin can be produced and grown.
The mould is expensive and production is time-consuming. Shipping to other countries takes a lot of space due to the mould design. With the redesign, the laser-cutted cardboard can be shipped as a flat package, but the assembly can take up more time. The assembly can be a challenge for mentally challenged people. This has not been tested yet.

7.2 Discussion

Looking back now at the main research question:

How can a mycelium funeral vessel be designed on a technical and experiential level to support and optimise its meaningful value in the funeral industry?

There is, on the basis of the research question, an extensive study carried out to find the needs of the stakeholders to support and optimise its meaningful value. It is questionable if the redesign listened to this need of every individual stakeholder. Emotional value depends on personal preference. Some might say the redesign creates meaningful value where others have a different opinion.

Although the concept Loop Cocoon fulfils most of the key aspects of the vision, the design challenge and requirements it does not seem to be the optimum for Loop Biotech since they are currently focussing on the production of the current coffin. The start-up already invested most of its time and money in the production of the current coffin.

In this aspect, the redesign does not mean that it is the easiest or most logical next step for Loop now, but rather a promising prospect of where the start-up could move to in the future.

7.2.1 Project evaluation

This graduation project is the most exciting and educational project done so far as an industrial design student.

This project did not start as a traditional IPD project and needed a different approach. Working with an innovative living material at a start-up was sometimes challenging. Mainly the contracts caused insecurities during the start and end of the project. It taught me always to make clear agreements and make sure everyone is on that same level of understanding.

Beforehand specific planning guided me into finishing within the 20 weeks the graduation project provides. It required adjusting the planning and defining the project more clearly after the mid-term. Some ideas were not included and recommended for further development due to time limitations. The project caused little stress for my mental health because of the strict planning and creating enough free time. Working at the office in YES Delft contributed to this feeling. For that, I am grateful.

This project brought a lot of educational and personal gain. I became knowledgeable in the work field of biodegradable material, which I did not expect to work with on this level. A hands-on and creative approach showed the power of different design perspectives.

7.2.2 Personal reflection

The professional and personal ambitions set in the preface are accomplished in this project. This project provided knowledge with the Material Driven Design method. The method proved to be a good fit for my own personal skills and interests. The creation of a final prototype shows to be more than development on paper or in words.

The support of a professor working in the end-of-life field gave me motivation and inspiration during the whole project. Marieke, being a supervisor for many years, has a lot of wisdom and knowledge and shows a way of designing that is both interesting and challenging.

The knowledge of a mentor familiar with automotive design showed me what forms and details could do to a shape to create a deeper meaning to a design. It showed me a more relaxed approach to my study and taught me that a result can be judged and evaluated better with a hands-on and explorative mentality.

I had the luck to spend most of my time at YES Delft. At this place, people are like-minded, and the tools and knowledge available provide many opportunities. Having the option to ask for feedback and validate ideas with Loop employees proved to be helpful. Not working from home taught me to create clear boundaries between the project and free time.

Another valuable lesson learned was I tend to work individually and not ask for feedback enough. I have the determination and making decisions on my own without the need for consultation. After ideation and a brainstorming session with the Loop team, conversations with family and friends provided new insights and showed helpful consultations.

A future goal is to be more open to the knowledge and perspectives others can give me. This can only improve the end result.

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