Innovative Sustainable Sneaker Design

Exploring an Adhesive-Free Construction Concept

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TIIVISTELMÄ

Tämän opinnäytetyön tavoitteena on kehittää kestävämpiä lenkkitossuja liimatonta rakennustapaa käyttäen. Tekijän kiinnostus kestävään suunnitteluun on motivoitunut tämän aiheen valintaan, jolloin tarkoituksena on syventää omaa osaamista ja ajattelutapaa kestävän ja innovatiivisen tulevaisuuden suunnittelussa.

Teoriaosuudessa käsitellään erilaisia teknisiä näkökohtia ja rakenteita, jotka ovat olennaisia liimatonta rakentamista ajatellen. Erityisesti keskitytään kestäviin rakentamismenetelmiin, joilla voidaan välttää liiman käyttöä. Tätä varten tutkitaan nykyisiä liimaamattomia rakenteita lenkkikenkien ja biomimetiikan avulla, jossa pyritään ymmärtämään, miten eläimet rakentavat kotinsa luonnollisista lähteistä.

Konseptisuunnittelu toteutetaan kriittisen muotoilun näkökulmasta, ja tavoitteena on kehittää uusi konsepti, joka on rakennettu ilman liimaa ja joka saa vaikutteita biomimetiikasta ja eläimistä. Konsepti perustuu kysymykseen "Mitä jos liimaa ei olisi?" ja sen muotokieli ammentaa inspiraatiota esimerkiksi Puma archive -lenkkareista.

Tuloksena saadaan uusi konsepti, joka esitellään luonnosten avulla. Tämä konsepti on suunniteltu ilman liimaa ja saanut vaikutteita biomimetiikasta ja eläimistä. Kaiken kaikkiaan tämä opinnäytetyö edistää kestävien rakentamismenetelmien käyttöä muotoilun alalla, ja tarjoaa uusia ideoita kestävämpään suunnitteluun.

Avainsanat Konsepti, Liima, Jalkine, Rakentaminen, Kestävä kehitys
Sivut 67 sivua

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Abstract

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ABSTRACT

The topic of this thesis is, to construct a sneaker Adhesive-free to get a more sustainable design. The thesis aims to explore a concept of sustainable construction by encouraging new ideas for designing in a more sustainable way.

The author's interest in sustainable design motivated the selection of this topic, with the goal of deepening their own skills, knowledge, and ways of thinking in a more sustainable and innovative way for the future.

The theoretical part of the thesis reviews the technical aspects of different closures and constructions of sneakers, with a focus on sustainable construction methods that avoid the use of glue. This is achieved through an analysis of existing non-adhesive constructions in shoes and biomimicry, which involves examining how animals build their homes using natural sources.

The concept design is explored through the lens of critical design. The result of this research is a concept that is built without glue and inspired by biomimicry and the design language of the Puma archive sneaker.

The concept is presented through sketches and is based on the critical design question: "What if there is no glue?" Overall, this thesis contributes to the development of sustainable construction methods in the field of design.

Keywords Concept, Adhesives, Footwear, Construction, Sustainability.
Pages 67 pages

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List of Abbreviations

DNA	Deoxyribonucleic acid
CAD	Computer Aided Design
PU	Polyurethane
EVA	Ethylene Vinyl Acetate
ISPA	Improvise. Scavenge. Protect. Adapt.
DFD	Design for Disassembly
TPU	Thermoplastic Polyurethane
3D	Three dimensions / three dimensional
CEO	Chief Executive Officer
AI	Artificial Intelligence

1 INTRODUCTION

"A designer has always been also a teacher, in a position to inform and influence the client. With the present environmental mess it is even more important that we help to guide the intervention of design with nature and humankind."

Papanek, V. (n.d.)

The purpose of this thesis is to analyse the construction of sneakers from a sustainable perspective, with a focus of finding alternative methods to construct them without using adhesives. To achieve this goal, the thesis first explores and compares different glues used in the footwear industry to understand why glue is commonly used and its impact on sustainability. Additionally, the thesis investigates existing non-glue construction methods used in shoe design. The study then examines the design language of sneakers from the Puma archive and conceptualizes ways to construct footwear without glue while maintaining the design Deoxyribonucleic acid (DNA) of the original Puma design.

The Inspiration for this approach comes from observing how animals build and construct their homes. The ultimate aim of this thesis is to deepen our understanding of sustainable and innovative design and possibly identify alternative solutions for constructing sneakers.

By encouraging people to think more sustainably in their design process and promoting the use of sustainable alternatives, we can make this approach more widespread and less of a passing trend. This thesis aims to contribute to this movement by presenting new ideas and perspectives to inspire more sustainable thinking and design practices in the future.

1.1 Research question

Exploring Sustainable and Adhesive-Free Construction Techniques for Sneakers

Research Question: How to design a sneaker with a more sustainable construction technique that does not rely on glue?

Sub-questions:

1. What is concept design and how can it be applied to footwear?

2. What does sustainability mean in the context of footwear design?

3. How are sneakers traditionally constructed and why is glue not sustainable?

4. What can we learn from natural sources and how can we apply those techniques to create a glue-free sneaker construction?

5. What are the challenges and limitations of designing and manufacturing a glue-free sneaker?

Figure 1. Frame of reference (Retrieved from Golden ratio, n.d.)

1.2 Structure and Research Methods

This interdisciplinary thesis integrates principles from both footwear design and the natural world, utilizing design principles from various fields.

Figure 2. Structure of the thesis

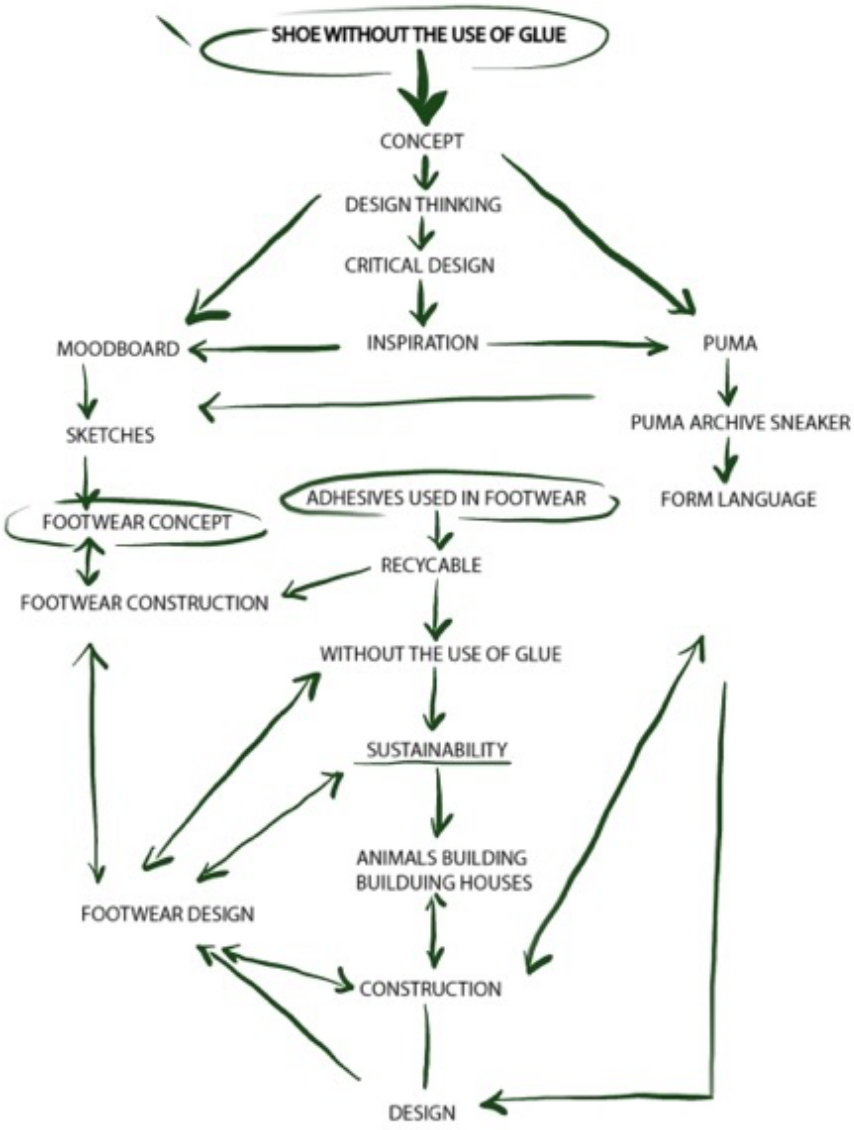


Figure 2 illustrates the structure of this thesis, which centers around developing a sustainable shoe construction method without the use of glue. The research process involves

exploring various fields to arrive at this concept, with a primary focus on leveraging biomimicry principles to find solutions inspired by nature's sustainable strategies. The findings from this research are outlined in 5.2..

1.3 Context

According to a study, a single shoe consists of 65 distinct parts that require 360 processing steps to assemble (Cheah et al., 2013, s.18). The use of stitching and gluing makes it challenging to recycle the various parts, resulting in less than 5% of the world's end-of-life shoes being recycled. The footwear industry generates approximately 1.2 million tons of post-consumer shoe waste each year, as reported by the Better Shoes Foundation (Better Shoes Foundation, n.d.-a).

Given the current challenges we face and the urgent need to adopt sustainable practices, the footwear industry must explore alternative procedures to construct shoes. The industry must move towards sustainable practices, considering the number and combination of materials, adhesives, and other toxic components in a shoe's life cycle. A non-glue construction may be a less harmful solution that makes it easy to deconstruct shoes and recycle them on a large scale. The Better Shoes Foundation emphasizes the importance of responsible chemical use to reduce environmental damage caused by leather tanning, petroleum oil extraction, and solvent-based glues. (Better Shoes Foundation, n.d.-a)

This thesis aims to address the construction of sneakers and alternative footwear constructions that do not require adhesive use.

1.4 Explanation of terms

- Upper: Refers to the part of the shoe that protects the upper surface of the foot. It can be made from various materials such as leather, plastics, or breathable fabrics. (Texon, 2016, p. 50)

- Vamp: The section of the upper between the toecap and the quarters, which includes the toe in the case of capless styles. (Texon, 2016, p. 50)

- Eyelet: A hole for lacing, which can also serve as a decorative feature. (Texon, 2016, p. 48)

- Insole: The insole of a shoe serves as the foundational component that conforms to the shape of the last, onto which the upper and bottom are attached. This lightweight layer must possess qualities of flexibility and moisture absorbency and can be constructed from a variety of materials such as leather, leather board, cellulose, and non-woven fiber board. Often covered by an in-sock, the insole plays a crucial role in ensuring both the comfort and longevity of the shoe. (Texon, 2016, p. 49)

- Midsole: The layer located between the upper and the outsole, which provides protection from impact forces generated during sports activities. (Texon, 2016, p. 49)

- Outsole or outersole: The first line of defense against forces resulting from contact with the ground. It contributes to cushioning and shoe stability, provides traction, and protects the foot from the ground. (Texon, 2016, p. 59)

- Shank: A shank is a structural element typically made of steel, fiber, wood, or leather that is placed between the outsole and insole at the waist of a shoe to preserve the curvature of the sole and prevent the heel from collapsing or sinking. (Texon, 2016, p. 50)

- Feather or fine edge: The boundary line where the welt or sole meets the upper, commonly referred to as the feather or fine edge. (Texon, 2016, p. 48)

- Footbed: An insert that is shaped or molded to match the contours of the bottom surface of the foot. Such insets are commonly used in trainers and sports shoes. (Texon, 2016, p. 49)

- CAD (Computer Aided Design): Refers to a shoe designed on a computer screen, which can then be modified, and patterns produced. Patterns can be cut according to the computer's instructions. Some systems can display 3D images of the designs. (Texon, 2016, p. 48)

- PU (Polyurethane): A synthetic soling material. Expanded PU is produced by mixing two chemicals to produce polyurethane foam. As little heat or pressure is involved, the molds are relatively inexpensive and easy to produce, allowing for relatively short runs. It is flexible and

used in bottom units that are soft, lightweight, wear-resistant, and slip-resistant. There is also a rigid version used for platforms. (Texon, 2016, p. 50)

- EVA (Ethylene Vinyl Acetate): EVA, is a versatile synthetic foam renowned for its outstanding shock absorption capabilities. Possessing rubber-like qualities, it is particularly well-suited for use in midsoles, whether in the form of blown or micro-cellular variants. Its lightweight nature and customizable properties, which can be adjusted by varying the proportions of ethylene and vinyl acetate in the co-polymer, make it a popular choice. Moreover, It is also used as the basis for adhesives. (Texon, 2016, p. 48)

- Direct molded: A construction method in which the sole, made of rubber, PU, or other moldable material, is molded directly onto the upper by vulcanization, injection molding, or reaction molding. (Texon, 2016, p. 48)

- Last: A solid form made of wood, plastic, or metal, which imparts its shape to the shoe. The upper, consisting of as many as twenty separate pieces, is sewn together and then placed on the last. When the sole is attached, the last is removed, and the inside dimensions of the shoe should conform to those of the last. (Texon, 2016, p. 49)

- Lasting: The process of stretching the upper over the last so that it conforms to the shape of the last while attaching it to the insole. (Texon, 2016, p. 49)

- Force lasting: The upper is formed into a bag, and the last is forced into it. (Texon, 2016, p. 49)

- Heat setting during lasting (Setting): This is a process where the upper part of a shoe is moistened and then dried using heat. The purpose is to fix the shape of the upper to the last in just a few minutes, and it can be removed as soon as the sole is fixed. In the case of synthetic uppers, this process is called heat-setting, which involves moistening or mulling the material to achieve the desired shape. (Texon, 2016, p. 49)

- Fusing press (Fusing): A fusing press is a heated press used to bond together components that are coated with heat-activated adhesive, such as hot melt adhesive. This is a critical step

in shoe manufacturing that ensures the proper attachment of various components. (Texon, 2016, p. 49)

- Recycled (Recyclable): This term refers to a finished product or waste generated during the creation process that can be reproduced and reused. In the context of sustainable manufacturing, this is an essential consideration as it helps to reduce waste and environmental impact. (Texon, 2016, p. 50)

- ISPA: Improvise. Scavenge. Protect. Adapt. (Nike, n.d.)

- Flyknit: Nike's Flyknit technology, introduced in 2012, is a material innovation that features a one-piece woven upper, resulting in a durable and lightweight product. (Janowski, 2022)

- Velcro: Velcro is a composite material comprising of two components that interlock via small hooked threads on one component and a coarse-surfaced fabric on the other component, creating a robust adhesion upon joining. (Mack, 2021)

- Biomimetic: “Biomimetics in the term for the use of natural models in technology innovation. In other words, in biomimetics, humans seek to use natural examples and natural systems to inform the process of building some technology.” (Rouse, 2019)

2 SNEAKER

According to the Cambridge dictionary, a sneaker is defined as a type of lightweight and comfortable shoe suitable for sports, characterized by a cloth top and a rubber bottom. (Cambridge Dictionary, n.d.)

The word "sneaker" derives from the notion of "sneaking", which originated from the introduction of rubber soles to replace loud and hard ones. This development dates back to the 19th century in both England and the United States, where sneakers were initially designed as low-cut shoes for sports. As such, the culture surrounding sneakers emerged from their association with athletics. (Maren, 2020)

Sneakers are a type of casual footwear that are designed for comfort and durability. They are typically made of materials such as canvas, leather, or synthetic fabrics, and feature rubber soles for traction and support. Sneakers were originally designed for athletic activities like running and basketball but have since become a popular fashion item worn for everyday activities. They come in a wide variety of styles, colors, and designs, and are often associated with youth culture and streetwear fashion. (Shuck, 2014)

2.1 Construction of a Shoe/ Sneaker

The central question of this thesis is How to design a sneaker with a more sustainable construction technique that does not rely on adhesives? To address this, the construction of sneakers and other conventional shoes are examined to demonstrate various processes and constructions. The aim is to illustrate the use of glue in shoe construction and consider this information during the concept phase. According to Ingevaldsson it is possible to build a shoe without glue, it is a complex process that requires a strong construction concept (Ingevaldsson, 2015). Further information on adhesives in footwear will be explored in the following chapters.

There are several types of sneaker constructions, each with its own unique features and benefits. Here are some of the most common:

Vulcanized: Vulcanized sneakers are made by bonding the sole to the upper using heat and pressure. This creates a durable, flexible, and lightweight shoe that is great for everyday wear. (Jane, 2016)

Cemented: Cemented sneakers are constructed by gluing the upper to the sole using a strong adhesive. This is a popular construction method for many shoes, as it offers a stable and comfortable base. (Shoemakers Academy, n.d.)

Slip-lasted or Race-lasting: Slip-lasted sneakers are made by pulling the upper over a last (a foot-shaped mold) and then attaching it to the sole. This creates a shoe with a snug, sock-like fit that is great for running and other athletic activities. (findsourcing, n.d.)

String lasted: The method involves sewing a string onto the bottom of a shoe upper, which is subsequently pulled taut to facilitate the stretching of the upper onto a last. Notably, this technique is applicable solely to fabric uppers and is typically cost-effective in nature. (Shoemakers Academy, n.d.)

Strobel construction/ California last: This technique falls within the Slip lasting or Force lasting category, whereby the shoe last is either "slipped" or "forced" into the upper. The upper is typically heated to increase its flexibility. The Strobel lasting method is also commonly referred to as California construction. The finalization of the lasting process involves inserting the last into the sock and subsequently bonding the sock to the sole with cement, in this particular case. It is also feasible to utilize other constructions, such as the Direct Injection process. Since the insock is stitched and not cemented to the upper, it imparts greater flexibility to the shoe, rendering it well-suited for various types of sneakers. The Strobel process is utilized almost exclusively for lasting running shoes and other athletic footwear, owing to its elastic and pliable attributes. (Findsourcing, n.d.)

Board-lasted: Board-lasted sneakers are constructed by attaching the upper to a stiff board, which is then attached to the sole. This creates a shoe with a firm, supportive base that is ideal for running shoes for example. (Shoemakers Academy, n.d.)

Overall, each construction method has its own unique benefits and drawbacks, and the choice of construction will often depend on the intended use of the shoe and the preferences of the wearer.

There are a few types of shoes that are typically constructed without the use of glue:

Stitched Construction: This is a traditional method of shoemaking where the upper, lining, and sole are stitched together using heavy-duty threads. This construction method is commonly used in durable and long-lasting high-quality leather shoes and boots.

Blake Construction: In this construction method, the upper is wrapped around the sole and then stitched directly to the insole. The outsole is then attached to the shoe using a

specialized machine. Blake construction shoes are typically lightweight and flexible. (Ingevaldsson, 2022)

Goodyear Welt Construction: This is a popular method of shoe construction where the upper is stitched to a welt, which is then attached to the sole. The welt acts as a buffer between the upper and the sole, making it easy to replace the sole when it wears out. Goodyear welt construction shoes are known for their durability and longevity. (Ingevaldsson, 2021)

Moccasin Construction: This is a type of shoe construction where the upper is sewn together with the sole in a single piece, wrapping around the foot like a sock. Moccasin construction shoes are typically very comfortable and flexible, but not as durable as other construction methods. (Oliver Sweeney, n.d.)

Keep in mind that some shoes may use a combination of construction methods, and not all shoes within these construction types are made without glue. It's always a good idea to research the specific brand and style of shoe you are interested in to determine its construction method and materials used.

2.2 Sustainable footwear

Sustainable footwear may be made from a variety of materials, including hemp, recycled polyester, linen, natural rubber, and recycled materials such as plastic bottles or old tires. Additionally according to Better shoe foundation, sustainable footwear may be designed for durability and repairability, to extend the product's lifespan and reduce waste. Overall, sustainable footwear is a way to reduce the negative impacts of the fashion industry on the environment and promote social responsibility while still providing consumers with stylish and functional shoes. (Better Shoes Foundation, n.d.-c)

Sustainability in footwear refers to the use of eco-friendly materials and production methods to minimize the environmental impact of the footwear industry. Here are some ways in which footwear can be made more sustainable:

Use of eco-friendly materials: The footwear industry can use eco-friendly materials such as organic cotton, hemp, recycled plastic, and other natural materials. These materials are sustainable because they require fewer resources to produce and have a lower carbon footprint. (Better Shoes Foundation, n.d.-d)

Sustainable production methods: The footwear industry can use sustainable production methods such as water conservation, renewable energy sources, and waste reduction. These methods can help to reduce the carbon footprint of the production process and minimize the environmental impact of the industry. (Better Shoes Foundation, n.d.-e)

Recycling and upcycling: The footwear industry can also incorporate recycling and upcycling into their production processes. For instance, old shoes can be recycled into new ones, and waste materials can be transformed into new products. This approach can help to reduce the amount of waste generated by the industry and conserve resources. (Better Shoes Foundation, n.d.-c)

Ethical labour practices: The footwear industry can also promote sustainability by implementing ethical labour practices. This includes ensuring fair wages and safe working conditions for workers, promoting gender and racial equity, and reducing the use of exploitative labour practices. (Better Shoes Foundation, n.d.-e)

Overall, sustainability in footwear involves a holistic approach that considers the environmental, social, and economic impact of the industry. By implementing sustainable practices, the footwear industry can reduce its environmental impact and promote a more sustainable future. (Better Shoes Foundation, n.d.-e)

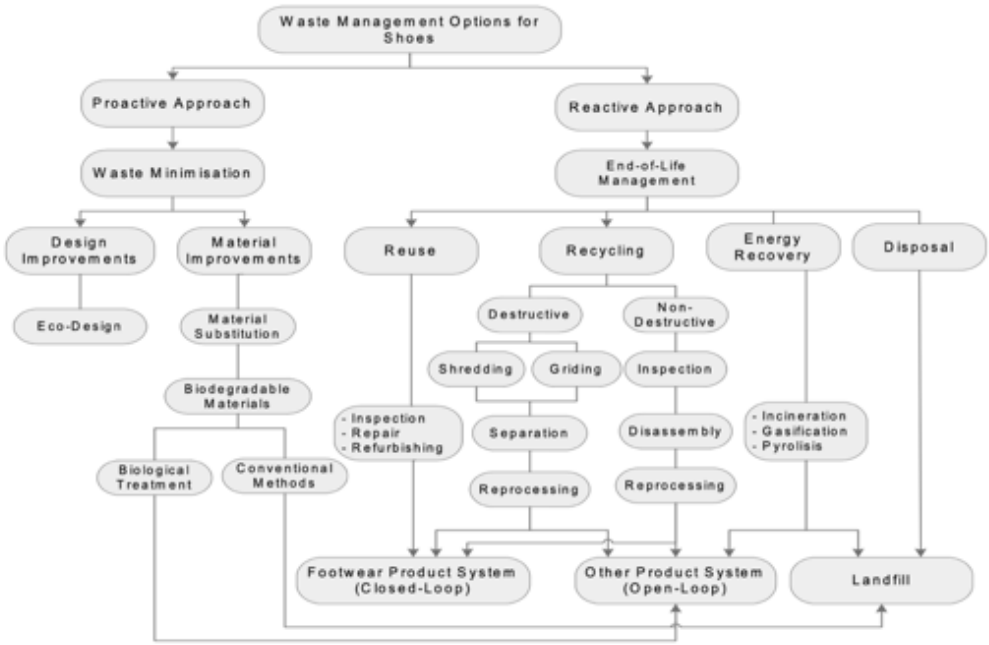
In order to address complex problems such as the climate crisis and overwhelming amounts of waste, it is often necessary to think outside the box and deviate from traditional methods. Simply adhering to conventional practices may not suffice in tackling these urgent challenges, as it was these very norms and routines that have led us to this dire situation. (Roberts, J. 2023) Hence, finding effective solutions may require breaking away from established conventions and exploring new and innovative approaches. As daunting as this may seem, it is imperative that we embrace this mindset if we hope to restore the health

and sustainability of our planet. (Papanek V., 2021(1995), 14) According to Victor Papanek design should be viewed as a connection between the needs of people, culture, and the environment. This implies that sustainable design should encompass more than just considering the materials and construction of a shoe, as well as its impact on the environment. It should also take into account the impact on people and consider resources and methods that prevent negative effects on both. One way to achieve sustainable design is by replacing virgin materials with recyclable materials, and replacing hazardous/toxic materials with non-hazardous alternatives (Ceschin & Gaziulusoy, 2020).

In considering what sustainable footwear entails, according to Papanek there are six important stages to examine that may have potential negative impacts on the environment. The first stage involves the choice of materials used in the design process, which can have far-reaching and long-lasting environmental consequences. Therefore, it is necessary to rethink the materials used in the production of footwear. The second stage involves the manufacturing process itself. This process may pose a risk to the workplace and workers due to exposure to toxic fumes from adhesives, as well as air pollution, soil, and water contamination. It is important to consider the potential negative impacts on workers and the environment when producing sustainable footwear. The third stage involves the packaging of the finished product. Packaging made from harmful materials such as used plastic should be replaced with more sustainable alternatives. The fourth stage concerns the production of multiple identical or similar products. It is important to consider whether so many products are truly necessary, and to aim for more sustainable production practices. The fifth stage involves transportation, which can have a significant impact on pollution. It is important to consider how products are transported and to aim for more sustainable transportation methods. Finally, the sixth stage involves waste. When the useful life of a product is over, it can have negative consequences that not only visually impact landscapes but also harm the environment. Thus, it is important to aim for more sustainable and eco-friendly waste disposal practices (Papanek, 2021(1995), p. 14,15,16,17). In order to understand what sustainability in footwear entails, we must first look at the history of shoe making. Since the beginning of the industrial age, shoes and their production have constantly evolved to meet changing needs and desires, driven by innovation. Moving forward, the shoe industry will continue to be shaped by individuals who are able to envision new possibilities and

recognize the potential of new materials and processes. However, what is even more crucial is that the shoe industry is guided by those who are aware of social and environmental challenges (Semmelhack, 2022, p. 48). Displayed in Figure 3 are various waste management strategies for shoes. sustainable footwear is not solely about the choice of materials used in the production of shoes. Rather, sustainability requires a holistic approach that considers all aspects of the production process, as well as the entire lifecycle of the footwear.

Figure 3. Waste Management Framework for Footwear products (Staikos, Heath, Haworth, Rahimifard, 2006)



To summarize Sustainable footwear is footwear that is designed, produced, and used in a way that minimizes negative impacts on the environment and society, and maximizes benefits for all stakeholders. This includes minimizing the use of natural resources, reducing carbon emissions and waste, ensuring fair labour practices, and using environmentally friendly materials and production methods.

Aden Schamees, a member of the Nike ISPA team, shared his insights during an interview with Future Now on the topic:

“Sustainability is centre to our work. With Nike´s Move to Zero and its goal of zero carbon and zero waste, we are constantly thinking about using recycled and sustainable materials in what we are creating. We also want to think about the afterlife of the shoes, how they can re-enter the system to be recycled or reused so that we can archive a circular economy. Shifting from a human-centered design approach to a more biocentric design approach that values all living things- the biosphere, plants, and animals.” (Shamees , n.d., p. 83)

2.2.1 The use of adhesives in Footwear

Adhesives play a critical role in shoe manufacturing, from the preparation stage to the assembly of different shoe parts. They are used in various steps such as attaching reinforcement elements, stitching constructions, and attaching shanks. However, not all adhesives are suitable for all types of shoes and parts. The footwear industry uses different types of adhesives, each with its own advantages and disadvantages. In this chapter, we will explore the three main types of adhesives used in traditional shoemaking and their specific uses and results. Firstly, it is important to note that shoe assembly often involves the use of binders, even if the shoe appears to be sewn together, as in a welted shoe (Ingevaldsson J., 2015). One of the earliest types of adhesive used in shoemaking is paste, which was initially water and starch-based. While paste products nowadays contain different contents, they are still always vegetable-based. One of the distinctive characteristics of paste is its slow-drying property, which requires it to be fixed during the drying process. Paste can be dissolved with water, but it needs more than just rainwater to dissolve completely. However, this property also makes it advantageous to use for toe and heel counters in leather, as it makes them hard and able to retain their shape, while also being easily reshaped if necessary. Paste also has its disadvantages. For example, it does not attach as quickly or harden as fast as contact adhesives, while also not holding as strongly as contact adhesives. (Ingevaldsson, 2015) The many different types of paste used in shoemaking each have their own specific advantages and disadvantages. For instance, it is possible to mix paste out of potato flour and water.

There are several types of adhesives used in the footwear industry, including (Grecoresin, n.d.):

Contact cement: This type of adhesive is used to bond materials such as leather, rubber, and foam. It is applied to both surfaces, allowed to dry, and then the surfaces are pressed together. (Ingevaldsson, 2015)

Hot-melt adhesive (HMA): Used for assembly, this adhesive is applied in a molten state and solidifies when it cools. It is often used to bond materials such as synthetic fabrics and leather. (Nanpao, n.d.)

Solvent-Based adhesives are in the footwear industry quite common, which is the problem because of its Hazardous chemical substances that are used in the manufacturing of adhesive for example Benzene and Toluene. Those are harmful for the environment and everybody working with them. According to reports, Chinese workers involved in shoemaking have been found to have significant exposure to harmful substances such as benzene and toluene, which are toxic solvents. Exposure to benzene, which is classified as a carcinogen, has been linked to respiratory system and brain damage. (Azari, et al, 2012, p. 44)

This is a complex problem and to work it out it requires other methods in manufacturing, shoe constructions that requires less or no glue at all would be a big step. A more sustainable solution for solvent based adhesives are non-solvent adhesives which are often for example water-based and with materials like Renia Aquilim 315 or Irutex TM FI 4006 1K those are Free from solvent. (Better shoe Foundation, n.d.-d)

2.2.2 Why a lot of adhesives are not sustainable

Adhesives used in the footwear industry are often not sustainable because they are made from synthetic materials that are derived from non-renewable resources, such as petroleum. Additionally, the production of adhesives typically involves the use of harmful chemicals and solvents that can be damaging to the environment and human health. (Azari, et al, 2012, p. 44)

Due to the presence of highly flammable chemicals and poor working conditions, several devastating fires have occurred in footwear factories, resulting in numerous worker fatalities. For instance, in 2015, a fire in a Philippine factory claimed the lives of seventy-two individuals (Industruall-union, 2015). Similar incidents have been reported in various other countries, including Bangladesh, India, and Australia, among others (Satra, n.d.).

Another issue with adhesives in the footwear industry is that they are often difficult to recycle or dispose of properly. This is because many adhesives are designed to be very strong and durable, which can make them resistant to breaking down or decomposing over time. As a result, they can contribute to the build-up of waste in landfills and other disposal sites. (Better shoe Foundation, n.d.-c)

Finally, the use of adhesives in the footwear industry can also have negative impacts on the quality of the finished product. For example, some types of adhesives may break down over time, causing the shoe to come apart or lose its shape. In addition, the use of adhesives can make it more difficult to repair or recycle shoes, which can lead to more waste over time. (Ingevaldsson, 2016)

Overall, while adhesives are an important part of the footwear manufacturing process, there are many challenges associated with making them more sustainable. To address these challenges, companies in the footwear industry are exploring alternative materials and production methods that can reduce the environmental impact of their products like the company VEJA (Veja, n.d.) and Allbirds (allbirds, 2021)

When contemplating one's own footwear, it is essential to reflect on their environmental impact beyond their usefulness. It begs the question of whether they were designed with recyclability in mind and what materials constitute their composition. Unfortunately, in the case of most shoes, the answers to these crucial questions are elusive, and there exists no proper avenue for their proper disposal. Consequently, the majority of discarded shoes ultimately contribute to polluting our environment. (Andersen, 2015) reasons for that are the most shoes are not made to be remade again.

2.3 Comparing sneaker with a non-glue construction

This chapter presents a few already existing shoe designs, which had the green design in mind, design for Disassembly (DFD) (Papanek, 2021(1995), p. 30). Designs that are constructed without the use of glue to be able to recycle.

2.3.1 Nike Considered line

Nikes considered boot, displayed in figure 5 was the Nikes first shoe which was designed with the intention to eliminate adhesives and other environmentally harmful materials. (Andersen, 2015) Nike Considered is a line of shoes that initially launched 2005, The considered Boot is Nike´s first concept shoe for its spring line. (Andersen, 2015) Designing product with a purpose, doing more with less. The depicted picture in figure 4 portrays the initial ideation phase of the process, visually captured on a board. Designing shoes for disassembly, as depictured on the Considered boot in figure 6. This shoe (Image on the left) is made from five pieces. The woven piece in the front, which is one piece and serves as a lacing system of the shoe. The outsole, the “cage” which is the black piece in the right corner of the picture above, which was designed for disassembly. The leather is made from vegetable dyed leather. (Clarke, 2016) This shoe from Nike was the inaugural product to be manufactured by Nike without the use of any substances or adhesives that could potentially harm the environment. (Andersen, 2015) The materials used in the production of these items are sourced locally, in close proximity to the factory. Additionally, a considerable amount of renewable materials, such as hemp fabrics, were utilized in their creation. It is currently infeasible to fully implement this comprehensive approach within our existing industrial systems, which are predominantly designed to operate under the linear economy paradigm (Ceschin & Gaziulisoy, 2020).

Figure 4. Nike Considered concept “Board” (Sabukaru, n.d.)

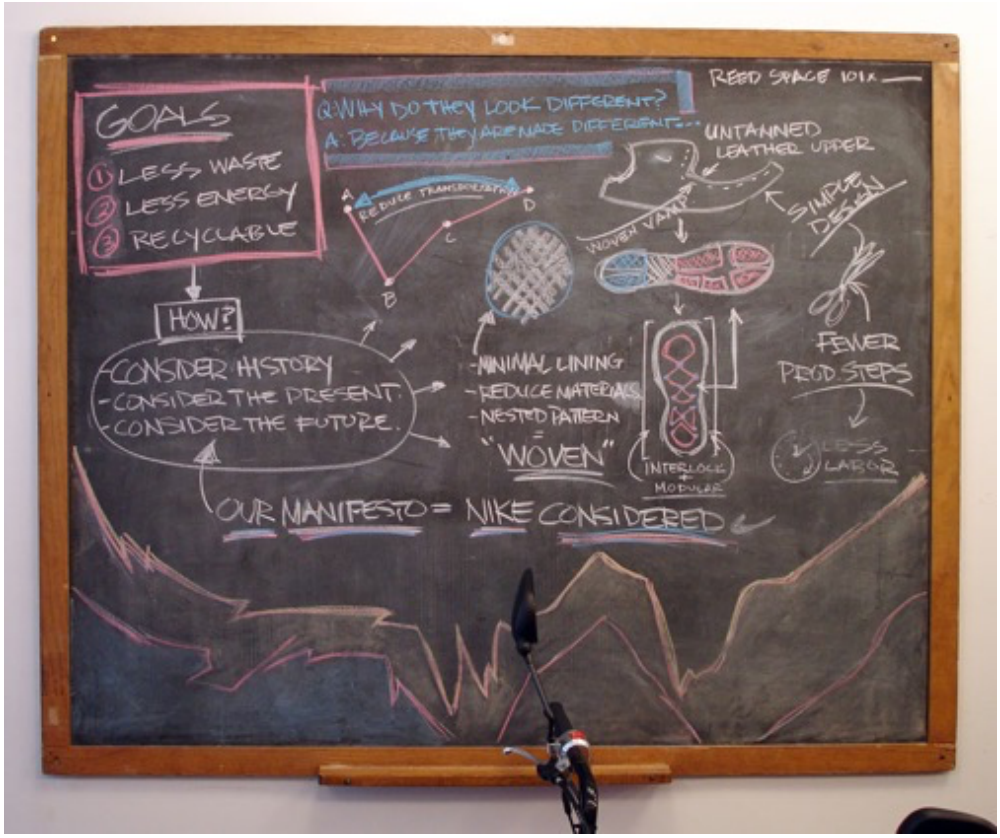


Figure 5. The final design of the Considered Boot (hypebeast, n.d.)

Figure 6. Exploded version of how Nike “Considered” is constructed (hypebeast, n.d.)

Having more in mind to solve a problem, Nike set 2018 some benchmarks (Kittner, 2012) which need to be filled in order to be qualified as *CONSIDERED:*

1 The use of recyclable materials is a must, this can involve using 100% recyclable plastics or vegetable-tanned leathers to ensure that the shoes can be easily recycled after use. By using materials that can be recycled, the environmental impact of footwear production can be reduced.

2 Zero Toxins: It is important to avoid the use of toxic materials in footwear production. This means using zero chemical adhesives, which can be harmful to the environment and human health. By avoiding toxins, the production process can be made safer for workers and the environment.

3 Mechanical solutions have to be considered as opposed chemical solutions. This involves using mechanics and engineering to put the shoe together, rather than relying on chemical adhesives. By using mechanical solutions, It is easier to recycle the shoe.

4 Closed Loop Technology, Closed loop technology is essential in footwear production. This means that the shoe can be remade into another shoe without going to waste. The shoe should be able to come back 100% as another shoe or something else, without any waste being produced. By using closed loop technology, the environmental impact of footwear production can be reduced (Kittner, 2012)

2.3.2 Nike ISPA Link

IMPROVISE. SCAVENGE. PROTECT. ADAPT. (Michael, 2022)

Figure 7. Nike Presto Clip (2003) lateral view (houseofheat, n.d.)

Nike Presto Clip, shown in figure 7 was the first sneaker where Nike embarked on the process of disassembly interlocking. Nike ISPA is the Sub-label from Nike and had its debut 2018 since then there have been released very interesting and much more, innovative shoes. “ISPA is kind of a collective. It´s a creative space in which to imagine future products and needs for the built environment. We explore social, political, environmental, and cultural movements as a starting point, too. Just how people think and feel, and what´s impacting

their lives and environments, from increasingly long commutes to the impacts of climate change in cities. We try to problem-solve using past Nike innovations, but also emergent innovations. And I think we try to respond with that and create products for these built environments." (Shames, n.d., p. 78) "We improvise against the unexpected, scavenge technologies internally within Nike, as well as externally to create adaptive and protective concepts." (Darryl, n.d., p. 79)

It is worth noting that the production of sneakers has a significant environmental impact, emitting approximately 13.6 kg of carbon dioxide in their cradle-to-grave journey, with roughly 70% of the emissions occurring during the manufacturing phase (Maju, 2022) In response, Nike ISPA released the Link sneaker in January 2022, featuring an interlocking modules system that eliminates the need for glue in its assembly. As claimed by the brand, the shoe requires only eight minutes to assemble, making it not only visually appealing but also environmentally sustainable in both manufacturing and usage (Maju, 2022). Nike ISPA represents a step towards a more sustainable and innovative approach to footwear, where creativity, problem-solving, and environmental consciousness are at the forefront of the design process, the figure below (Figure 8) is presenting the sneaker from different views.

Figure 8. Nike ISPA Link Sneaker different views. 1. Top left corner, detail from the bottom of the shoe. 2. Top right, top down view. 3. On the right side n the middle, view from the bottom. 4.On the bottom, lateral view of the shoe.

Figure 9. Nike ISPA Link disassembled in its three components (Nike, n.d.)

The Image above figure 9 shows the three dissembled components of the Nike ISPA Link. “The ISPA link series features three interlocking modules with an ultralight mid-sole of uneven pegs that seamlessly fit the knitted fabric upper skin and interlink to form a whole” method (Maju, 2022). With this shoe, ISPA link is using the traditional cut and sew Nike is going one step towards more sustainable fashion.

2.3.3 Nike ISPA MindBody

The Nike ISPA MindBody was released on February 24,2023 and is the third shoe in Nike´s ISPA line. This design is constructed with interlocking components with the same intent as with the ISPA Link to use less materials and designed with a product end of life in mind. With this concept Idea the ISPA MindBody can be easily disassembled, the shoe is stitched together with just one cording system that holds it all together. Which means it is easy to rip them apart, getting their constituent parts which helps the recycling process. (Roberts, 2023)

Nike's ISPA MindBody shoe is designed with a circular design philosophy, similar to Nike Link and Link Axis, with a focus on end-of-life product considerations. The shoe's upper is made of stretchy and supportive FlyKnit, using recycled yarn instead of new materials. The footbed is a lofted FlyKnit, which offers exceptional comfort in lieu of traditional sockliners (nike, n.d) The midsole is constructed of foam for added cushioning and is made from rubber scraps sourced from factory floors. A toggle switch lacing system holds the shoe together (Cheung, 2023). According to Nike's website, the MindBody design reflects the company's commitment to sustainability and human-centered design. The shoe's circularity and connectivity features are intended to make a positive impact on the world as visualised in (Figure 10). Product disassembly and proprioception, the awareness of how your body moves and interacts with the environment, are integral to the MindBody design and represent the next evolution of footwear (nike, n.d.)

Figure 10 - Nike ISPA Mindbody mood picture (Teamx7, Nike, n.d.)

Nike´s ISPA MindBody shoe presented in figure 11 and sketched in figure 12, offers a unique combination of comfort, sustainability, and innovative design. By focusing on circularity and human-cantered design, Nike continues to push the boundaries of what´s possible in the world of footwear.

Figure 11. Nike ISPA MindBody in Olive Grey, 1. On the top, the lateral view of the shoe, 2. In the middle, shoes from the back/side 3. Bottom view of the shoe. (Own illustration based on Nike, n.d.)

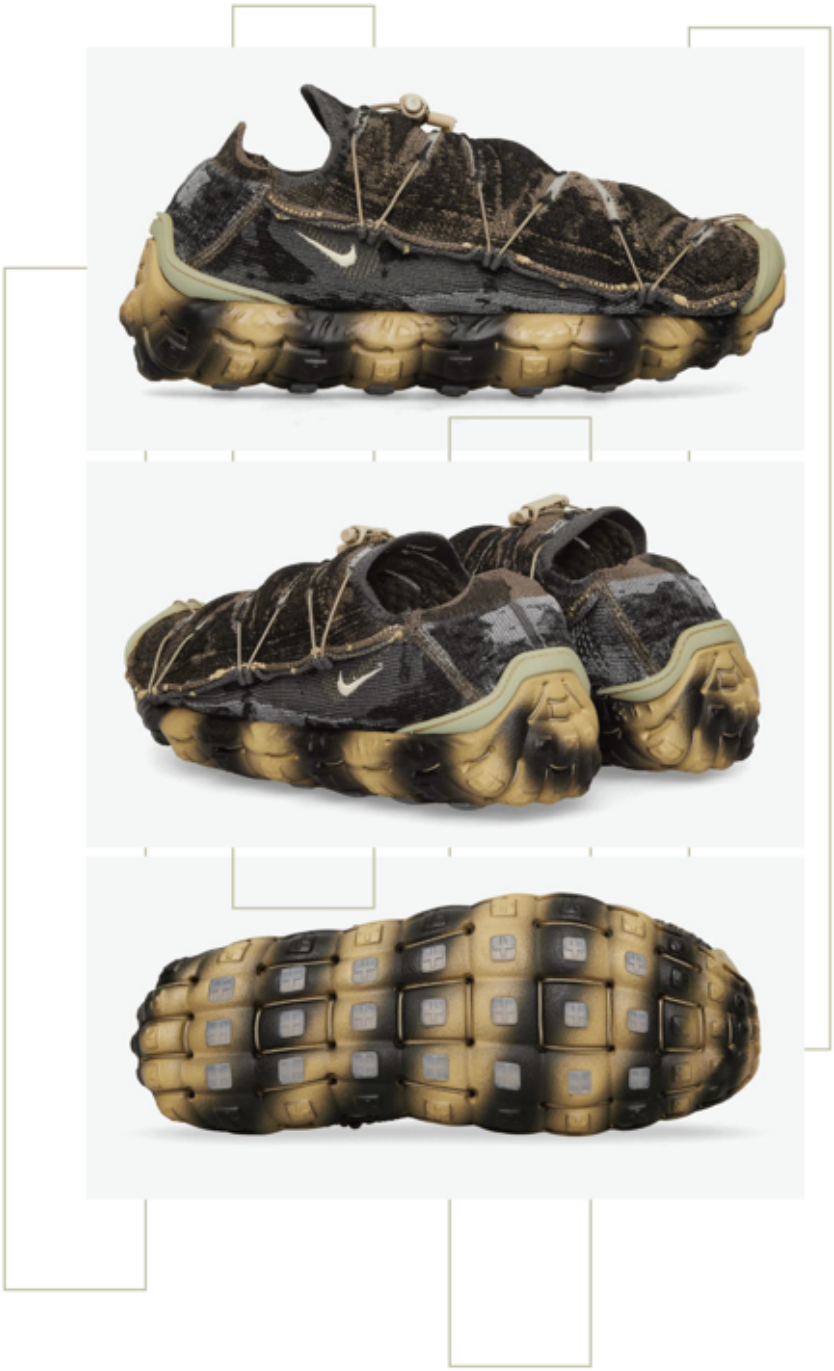


Figure 12. Sketches of Nike ISPA Mindbody (Teamx7, Nike, n.d.)

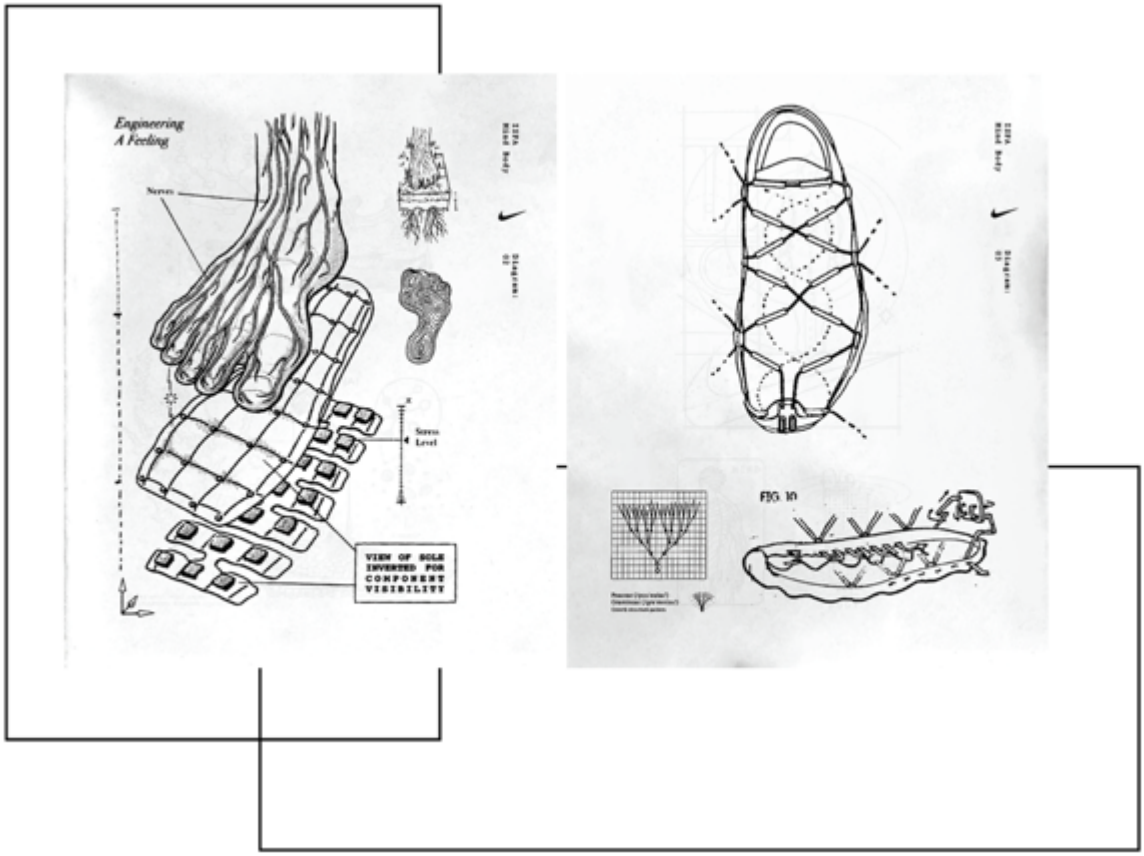
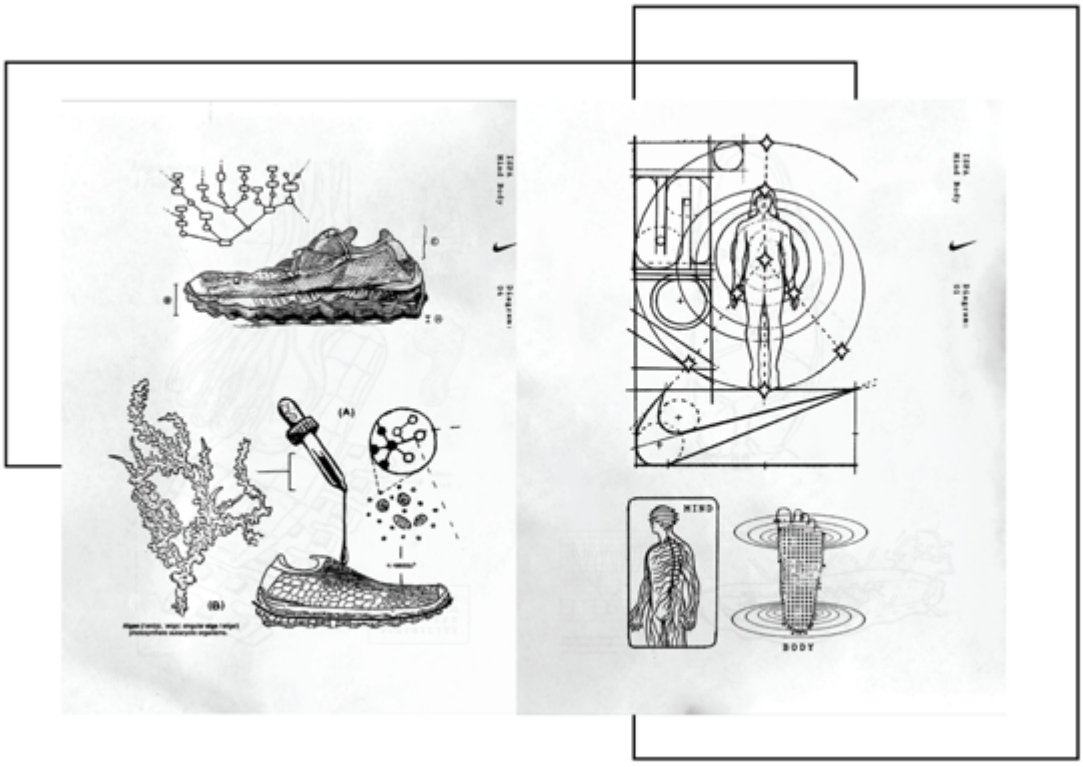


Figure 13. Nike ISPA MindBody Barely Volt (Nike, n.d.)

Nike ISPA MindBody *Barely Volt* presented in figure 13, this style is made in partnership with Living Ink, the biomaterials company that uses algae ink as an alternative to petroleum-derived inks. The knit construction has been infused as shown in sketches in (Figure 14), with algae which gives a sustainable finish. (Cheung, 2023)

Figure 14. Nike ISPA Mindbody sketches of Barely Volt algae ink coloration and on the right mood picture for “Mindbody” (Teamx7, Nike, n.d.)



2.3.4 Nike Link Axis

Nike ISPA Link Axis, which is presented in figure 15, is going to arrive 2023.

Figure 15. Nike ISPA Link Axis (Sneakernews, Nike, 2022)

The Link Axis shoe will have a precise fit between its outsole and the 100% recycled polyester Flyknit upper, achieved through careful engineering. To create the shoe's Thermoplastic Polyurethane (TPU) tooling, scrapped airbag material will be upcycled. Apart from using recycled materials, the shoe's unique rugged look will be enhanced by assembling it without glue, which eliminates the environmental impact of the heating and cooling

process typically used in shoe production. Furthermore, this method avoids the energy costs associated with shredding and recycling conventional sneakers (Maju, 2022).

2.3.5 Zellerfeld Shoes

When evaluating shoes that are made with a sustainable approach and end-of-life in mind, it is worth considering shoes with a non-glue construction that are 3D printed. By utilizing automated printing, there is no need for overseas factories and labor. Additionally, since each pair of shoes is printed to order, there is no excess or waste. In terms of end-of-life considerations, Zellerfeld shoes are designed to be 100% recyclable. This means that old pairs can be returned and fully recycled into new ones, thereby minimizing waste and reducing the environmental impact of the footwear industry. (Zellerfeld, n.d.)

Figure 16. Finn Rush-Taylor Nami Picture of the shoe from Its beta platform (Zellerfeld, n.d.)

Zellerfeld, an industry leader in 3D-printing and innovative footwear technology, has recently launched an open beta program which aims to provide unrestricted access to 3D-printed footwear to the general public one of the available styles is Finn Rush-Taylor Nami which is shown from different sides in figure 16. The platform is an extension of Zellerfeld's earlier closed beta initiative, in which a group of designated testers offered feedback on the 3D-printed footwear and manufacturing procedures. The open beta program not only offers a new supply avenue for designers and brands but also helps eliminate sweatshops and the associated human rights violations. (Zellerfeld, n.d., Li, 2023)

According to Cornelius Schmitt, Co-Founder and chief executive officer (CEO) of Zellerfeld, the company is proud to break down the barriers to entry for designers and offer a platform that enables experimentation. This is a revolution in the footwear industry, providing an ethical, sustainable, and design-led future for footwear. Zellerfeld is confident that their open beta program is the future of the footwear industry. (Zellerfeld, n.d., Li, 2023)

Figure 17. Zellerfeld x Heron Preston, HERON01 (Verion 0.8 >>> 0.81 Update) (Zellerfeld, 2021)

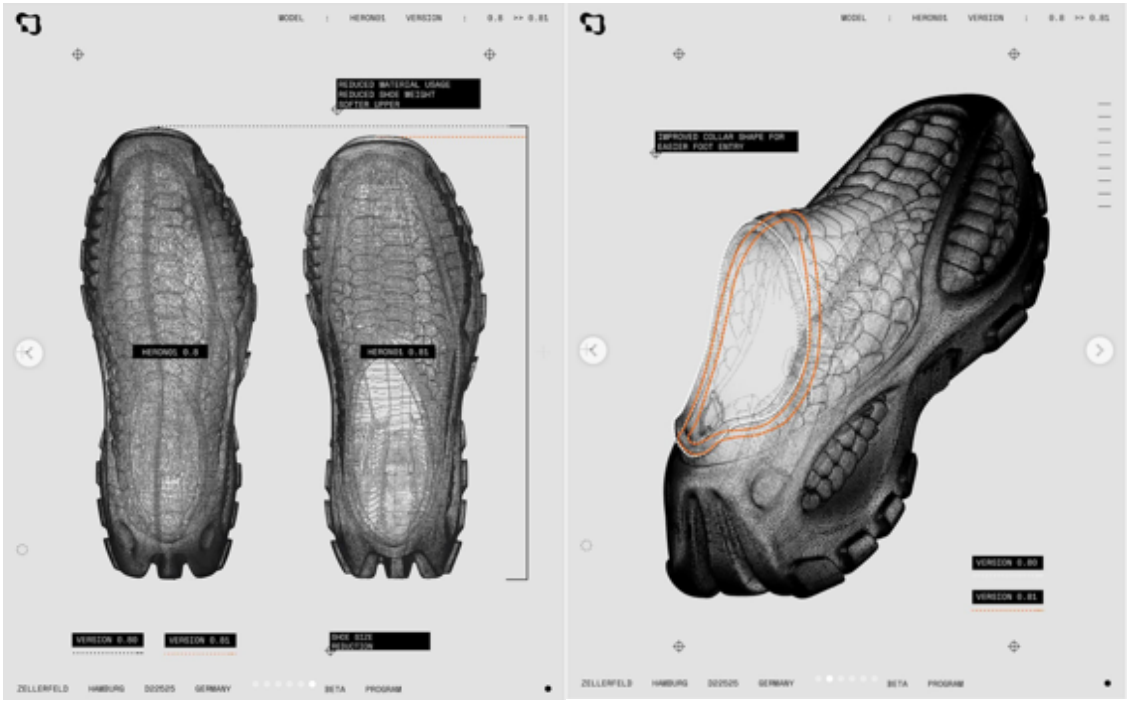
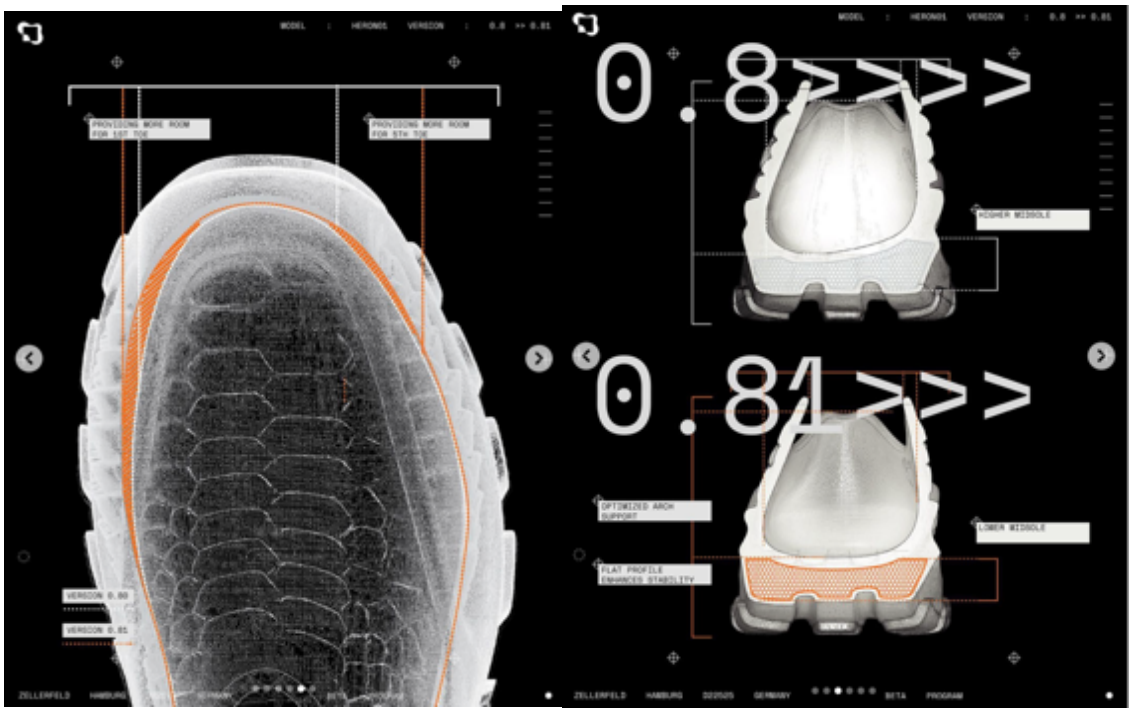


Figure 18. Zellerfeld x Heron Preston, HERON01 (Verion 0.8 >>> 0.81 Update) (Zellerfeld, 2021)



Currently, Zellerfeld's Hamburg facility is producing pairs of custom-printed shoes for various brands in the 3D-printed footwear industry, the Figures above figure 17 and figure 18 shows some changes on a shoe which is in collaboration with Heron Preston. The TPU material used in the printing process is highly detailed, allowing for intricate designs on both the upper and sole of the shoe while still maintaining a one-piece construction. However, despite its soft and flexible nature, the TPU material also possesses a certain level of tackiness that could potentially cause blisters on bare skin for some individuals with certain skin types. (Voung, 2023)

2.3.6 Camperlab Tossu

Camperlabs Tossu shoes, presented in figure 19, produced by Camper, a Spanish footwear brand. The shoe is made out of a rubber outsole which elements going into the upper with a 3D knit sockliner made from recycled polyester. This shoes fully recyclable thanks to its construction which avoids any use of glue. Additionally, It is manufactured and designed in Spain. Displayed in figure 20 are various process images of the Tossu shoe.

Figure 19. Caperlab Tossu Shoe (Camperlab, 2021)

Figure 20. Process picture of Tossu (Horcikova, 2022)

2.3.7 Adidas Y-3 ITOGO

“ITOGO” the name is set together from the Japanese words for thread – “Ito” and Five “Go”.

The Adidas Y-3 ITOGO Sneaker is a shoe in collaboration between Adidas and the Japanese fashion designer Yohji Yamamoto. Arriving March 2023 Adidas introduced a shoe that is composed of five distinct components, each numbered for easy identification, the components are displayed in figure 21 and the shoe ready to wear is displayed in (Figure 22) from different views. The upper is made of a Knitted Upper (Primeknit) that has been stitched together with the Rubber Cupsole and features elastic straps to provide additional support. Nestled between the upper and Cupsole lies a Boost Midsole.

Figure 21. Adidas Y-3 ITOGO Sneaker decomposed into its five components: Boost midsole, Elastic straps, Knitted upper, Thread, Rubber cup sole (Sneakerjagers, 2023)

Figure 22. Adidas Y-3 ITAGO Sneaker, on the left side top down view, on the right the view from the back lateral and medial view (Adidas, 2023)

According to Adidas: “Designed as a provocation to rethink the lifecycle of footwear, and forgoing the use of glue, each component is then assembled using a hand-stitched process- resulting in a silhouette that can be fully dismantled if the owner decided to cut the threads.” (Adidas, n.d.) Overall, the Y-3 ITOGO shoe presents a blend of design and sustainability, trying to push the boundaries of traditional footwear and offering a new perspective on the future of shoe production. The figures presented above offer a comprehensive depiction of the shoe design process, which begins with the moodboard illustrated in figure 23, progresses to the initial concept sketches showcased in figure 24, and culminates in the first prototype featured in figure 25. The subsequent modifications made to the prototype, leading up to the final design, are illustrated in figures 26 and figure 27.

Figure 23. Moodboard of Adidas Y-3 ITAGO Sneaker (Behance, Longo, 2023)

Figure 24. Original sketch of Adidas Y-3 ITAGO Sneaker concept (Behance, Longo, 2021)

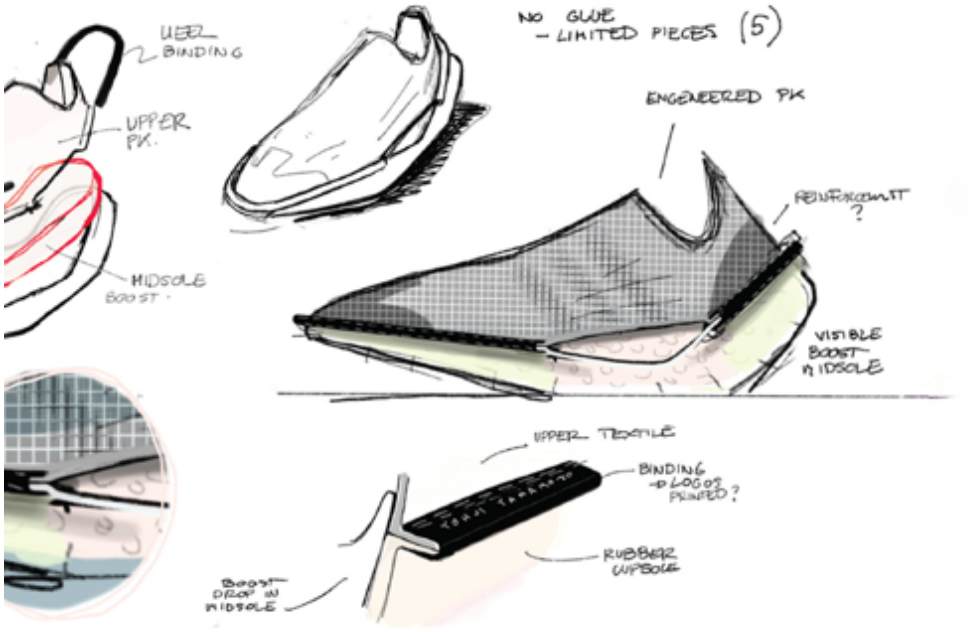


Figure 25. First Sample of Adidas Y-3 ITAGO Sneaker (Behance, Longo, 2021)

Figure 26. Process pictures of Adidas Y-3 ITAGO Sneaker (Behance, Longo, 2021)

Figure 27. Process pictures of Adidas Y-3 ITAGO Sneaker (Behance, Longo, 2021)

2.4 Comparing results of sneakers

The aforementioned tables, table 1 and table 2, offer a portrayal of the compared styles, illustrating the components employed in each style and highlighting the primary construction components of the shoe. Upon examining the shoes and their descriptions, it becomes apparent that there are certain aspects of the shoe that raise questions about the number of components and materials used in their construction. For instance, the upper may contain stabilizing elements for the knit, as seen in the Nike ISPA and Adidas ITAGO, and small details such as numbering on the pieces, branding on the strap, and the edge where the upper and strap are stitched together, as observed in the Adidas ITOGO. This leads to the question of how many components comprise the upper and whether it can be recycled as a single piece given that it is made of the same material, or if other materials are also present.

Despite the unique approach of each shoe discussed, they share a common goal of promoting sustainable footwear through innovative solutions, superior materials, and thoughtful design. These approaches are significant steps towards a more sustainable future and demonstrate the dedication of designers who are committed to pushing the boundaries of sustainable fashion. By thinking ahead, these designers are making meaningful contributions to the evolution of sustainable footwear.

Table 1. General overview of sneakers compared with a non-glue construction.

Comparing sneaker with a non-glue construction

GENERAL OVERVIEW

STYLE NAME:	STYLE PICTURE:	COMPONENTS:	CONSTRUCTION:
NIKE CONSIDERED BOOT		five components	stitching Woven interlocking system
NIKE ISPA LINK		three components	Flyknit interlocking modules
NIKE ISPA MINDBODY		three components	Flyknit single cording
NIKE ISPA LINK AXIS		five components	Flyknit interlocking modules

Table 2. General overview of sneakers compared with a non-glue construction.

Comparing sneaker with a non-glue construction

GENERAL OVERVIEW

ZELLERFELD FINN RUSH-TAYLOR NAMI		One component	3D Print
CAMPERLAB TOSSU		?	3D-knitted sock lacing system
ADIDAS Y-3 ITOGO		five components	stitching Primeknit elastic band

3 BIOMIMETIC DESIGN

"we humans are proud of our inventions. but can we discern greater merit in our builders who unconsciously follow their instincts? the evolutionary roots of human behaviour reach far back into the behaviour patterns of animals. Those who are fascinated by these connections need only fasten on one such puzzle, the architecture of animals perhaps, to find an absorbing interest for a lifetime. Gradually they may learn to understand a great deal that at first sight appeared incomprehensible, and to people of an inquiring cast of minds, this will afford deep satisfaction. and yet the sum total of unsolved mysteries will always remain

immeasurably greater than the sum of our discoveries. there are biologists who are convinced that they, or future generations of scientists, will ultimately find the key to life in all its manifestations, if only research preserves. they are to be pitied. for they have never experienced that sense of profound awe in the face of the workings of nature, some of which will forever elude comprehension, even by the mind of man." (von Frisch, n.d., p. 2)

Biomimetics (also known as biomimicry or biologically inspired engineering) is an interdisciplinary field that studies nature's designs, processes, and systems to inspire the development of new technologies, materials, and strategies that solve human problems. Biomimetics takes inspiration from the principles of biology, such as natural selection and evolution, and applies them to engineering, architecture, medicine, and other fields. Biomimetic solutions often involve the replication or adaptation of natural forms, functions, and processes, such as the structure of bones, the adhesion properties of gecko feet. By emulating nature's solutions, biomimetics aims to create more sustainable and efficient technologies that work in harmony with the environment and promote ecological and social well-being. (Bernett, n.d.)

Biomimicry in footwear design is the practice of drawing inspiration from nature's designs and applying them to the design of shoes. The goal is to create shoes that are more comfortable, durable, and sustainable. biomimicry in footwear design is an innovative approach that has the potential to create among other things more sustainable and functional footwear. Biomimetic footwear design is an area of research that has the potential to revolutionize the way we think about and design shoes. By incorporating principles from nature and the human body, designers can create shoes that are not only more comfortable and supportive, but also more sustainable and environmentally friendly.

Biomimicry is a method used to create sustainable designs by drawing inspiration from nature's proven strategies. This approach has been widely used in various fields, such as product design, transport, architecture, computers, agriculture, and city planning. (Penny, n.d.) The creation of Velcro by Swiss engineer George de Mestral in 1941 is a famous example of biomimicry. De Mestral noticed how burrs attached to his clothes and dog's fur during a walk, and upon examination, he realized that the burrs' tiny hooks stuck to the

fabric's loops. This observation inspired the invention of Velcro, a fastening technology that is now ubiquitous. (Mack, 2021)

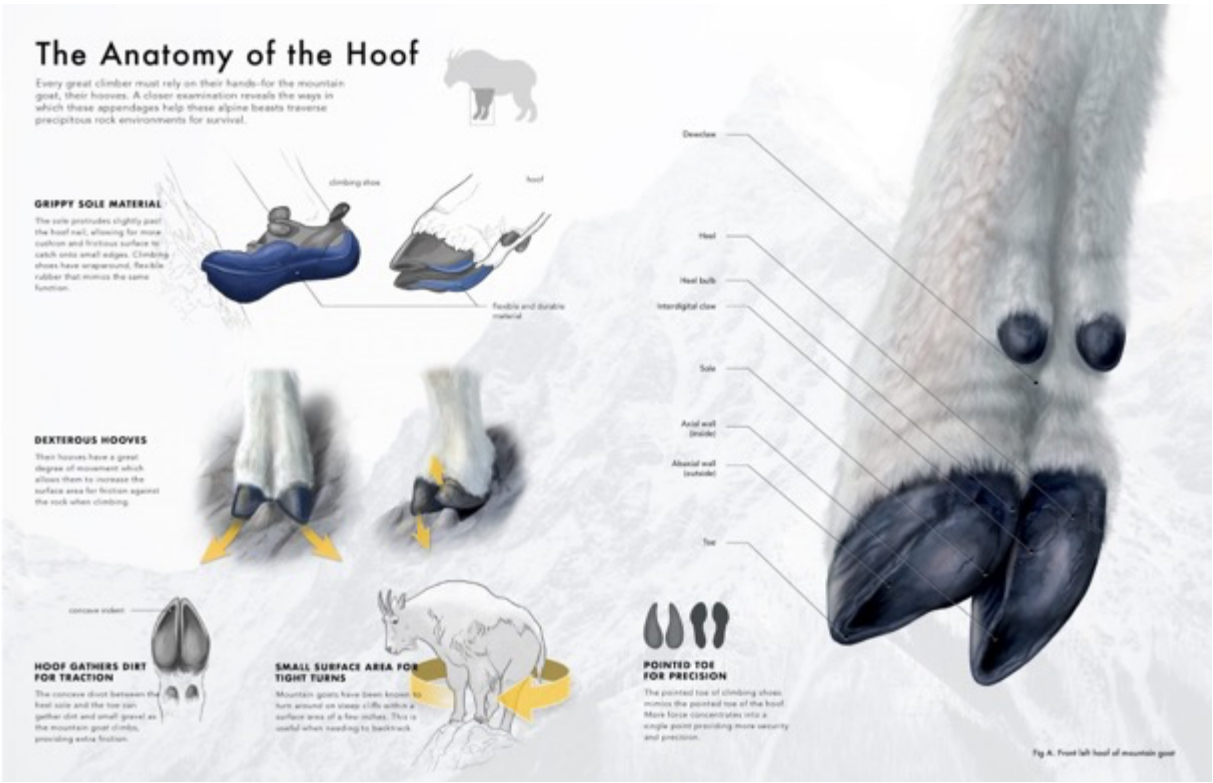
An instance of biomimicry in design is the Nike Air Terra Goatek footwear, showcased in figure 28, which draws inspiration from the hooves of mountain goats, as evidenced in figure 29. The shoe's designers mimicked the evolutionary makeup of a mountain goat's hoof to create the G-Tek traction technology. The sole of the shoe provides excellent grip on uneven terrain, much like the mountain goat's hooves. The Nike Air Terra Goatek demonstrates how biomimicry can create sustainable solutions to design problems by drawing inspiration from nature. (Penny, n.d.)

Same principle from the Mountain Goat Hoof anatomy shown in the Graphic figure 30 below by Tiffany Fung.

Figure 28. Nike Air Terra Goatek (Concept Kicks, n.d.)

Figure 29. Nike Air Terra Goatek, top down view (Concept Kicks, n.d.)

Figure 30. Graphic of the Anatomy of the Hoof from a Mountain Goat (artthescience, Fung, 2020)



Biomimicry is an innovative approach to sustainable design that enables designers to create solutions by imitating nature's designs and processes. The examples of Velcro and the Nike Air Terra Goatek highlight the effectiveness of biomimicry in creating functional and sustainable solutions in real-world applications.

We take inspiration from the nature, we learn from the nature and we find solutions to problems we are facing, in the nature, therefore this thesis takes a look on the animal world to look for possible solutions for the construction of the shoe.

4 PUMA ARCHIVE SNEAKER

Puma Cell Flexion Shoe the Midsole comes originally from 2005-2006 as shown on the two styles (Cell Deka and Cell Addo) below in figure 31 and figure 32.

Figure 31. Puma Cell Deka (Puma archive, n.d.)

Figure 32. Puma Cell Addo (Puma archive, n.d.)

The design language for the concept sneaker comes from a PUMA archive shoe. The style from Puma is a running style called Cell Flexion which is showcased in figure 33 and figure 34. There is not a lot of information provided of this style. The upper is made of synthetic materials. The insole material is Foam and the outsole rubber. It has a lace up as a closure. The midsole from this style comes from 2005-2006, as shown in the figure 31 and figure 32. The purpose was to find a sneaker from Puma with an interesting form language. The choice of this Archive running shoe was made because of its interesting components and forms, especially the structure on the upper and tooling, was interesting. At the same time thinking of a form language that can be used or transferred into the concept.

Figure 33. Puma Cell Flexion Shoe from different views (Roy, n.d.)

Figure 34. Puma Cell Flexion Sneaker (Plantvintage_official, 2023)

5 CONCEPT DESIGN

Design thinking involves expanding options rather than narrowing them down. (Brown, 2019, p. 235)

Moving on to the concept design phase, this chapter aims to define and explain what concept design means and how it fits into the design process. Concept design can be understood in different ways depending on the creative field in which it is used. In the context of product development, concept design involves identifying the problem that the product aims to solve and exploring various ways in which it can be addressed. “The more the better. In concept design lies the very soul of innovation.” (Hedges, 2017)

Concept design represents the earliest, most creative phase of the design process. In this phase, there are no constraints or limitations, and designers are encouraged to think big. According to Rudeck “This phase is ´big picture` thinking without getting bogged down in technical detail. This stage of the process confirms the product requirements. The designers know what problems need to be solved, and they´re subsequently able to brainstorm how the product will address them.” (Rudeck, 2022)

The term 'concept design' is the combined of the word’s 'concept' and 'design.' It refers to the idea and intention behind the design, as well as the form, shape, and look of the idea. It is crucial to understand the type of design that the concept is related to. This thesis focuses on the term 'critical design,' which will be discussed in the next chapter.

5.1 Critical thinking

This chapter will focus on the importance of critical design and its relevance in contemporary design research. Critical design is an innovative design methodology that seeks to challenge and disrupt the conventional assumptions, preconceived notions, and established norms surrounding the role of products in everyday life. This approach aims to foster creative and thought-provoking solutions by questioning the status quo and considering alternative perspectives. The term "critical design" was coined by Anthony Dunne and Fiona Raby in the

mid-1990s when they were researchers at the Royal College of Art's Computer Related Design Research Studio. Their definition was back then that “critical design uses speculative design proposals to challenge narrow assumptions, preconceptions, and givens about the role products play in everyday life.” (Dunne, Raby, 2013, p. 34) In this chapter, the concept of critical design and its significance in design practice are analyzed.

Anthony Dunne and Fiona Raby view critical design more as an attitude or position rather than a methodology It is an approach that questions what is given by society and critiques norms. Critical design is not meant to become a design label but rather an activity or style. The term "critical design" has gained relevance again in design research in recent years, but it is not understood as overly negative critique. Instead, it is a questioning of why we design and the values we bring to design practice. These term focus on presenting abstract issues as fictional products to explore ethical and social issues within the context of everyday life. (Dunne, Raby, 2013, p. 34-35)

The main thought of critical design is “Speculating through design by presenting abstract issues as fictional products enable us to explore ethical and social issues within the context of everyday life.” (Dunne, Raby, 2013, p. 108) It is a way to open up a space for discussion rather than predict how things will be. There should be space for people to form their own opinion to make up their own thoughts about what kind of future they think of. “Critique is not necessarily negative; it can also be a gentle refusal, a turning away from what exists, a longing, wishful thinking, a desire, and even a dream. Critical design are testimonials within existing normality.” (Dunne, Raby, 2013, p. 5)

According to Mitrović, engaging in speculative design as an approach and practice can be an effective method for exploring the uncharted territories beyond the present and the immediate. This approach is highly stimulating and can yield valuable insights. (Mitrović, 2015, p. 9) This strategy can help designers expand their horizons and identify emergent themes that can inform their design concepts.

“We are problem-solving for people in cities. I think our starting point is from a human mindset sensibility. That´s the starting point for us. We try to explore the way we live in these kinds of urban environments. We consider the future of these spaces, the different

weather conditions faced, or how they all evolve and change. We examine these ideas through the materiality of the product. We explore different types of materials that can help in these environments. It is not always grounded in questions like, oh, we need to problem solve for this traction issue that you might have in the city. Instead, we are more speculative about the future materials or cities and environments." (Shamees, n.d., p. 80, 83)

To conclude, critical design stands as a crucial approach in design practice that challenges established assumptions, preconceptions, and conventions about the role of products in daily life. It prompts designers to question societal expectations and critique established norms. Rather than being limited to a design label, critical design functions as a style or activity. Through the creation of fictional products that address abstract issues, critical design empowers designers to investigate ethical and social dilemmas within the realm of ordinary life and create room for conversation.

5.2 Adhesive free sneakers concept

"We can´t predict the future but we can imagine, invent it design it. Because we know sustainability is the innovation challenge of our lifetime" (Nike, n.d.)

The development process of the non-glue sneaker concept undergoes several distinct stages. Firstly, a comprehensive moodboard is crafted to provide a clear framework for the idea, which is informed by various facets of the thesis. Secondly, artificial intelligence (AI) is employed to conduct preliminary experimentation, thereby potentially inspiring the structure of the sneaker. Finally, the initial concepts are fleshed out through ideation and sketching, leading up in the creation of a definitive design.

5.2.1 Moodboard

The beginning of the design process typically involves the creation of a moodboard, whereby the designer collects visuals to spark inspiration. The concept's moodboard draws significant inspiration from the world of bees and wasps, including their unique houses and structures.

Additionally, figure 34 showcases a diverse array of tooling's, technology, structures, and forms that further augment the concept's visual language.

Figure 34. Moodboard

5.2.2 Inspiration from Artificial Intelligence

The Figures presented in this section figure 35, 36, 37, 38 are showcasing renditions of shoes, each generated through the application of Artificial Intelligence (AI). These AI-generated shoe designs have been crafted using the textual constructs outlined in the thesis, with the goal of new and unconventional approaches for sneaker construction. In these design trials, materials and colours was not important, the focus was directed towards the construction of the sneaker.

Figure 35. All Figures are AI generated pictures of sneakers (Midjourney, Bierbaums, 2023)

Figure 36 All Figures are AI generated pictures of sneakers (Midjourney, Bierbaums, 2023)

Figure 37. All Figures are AI generated pictures of sneakers (Midjourney, Bierbaums, 2023)

Figure 38. All Figures are AI generated pictures of sneakers (Midjourney, Bierbaums, 2023)

The results show interesting pictures which however hardly contributed to the further development of the concept, as they look very much like glued shoes and therefore do not have the right approach for this concept. this may also be due to the fact that the development of adhesive free shoes with for example modular systems is still very much in

its infancy and AI therefore presents the classic cemented shoes as a picture. However, there are still elements in the images that are interesting especially in the tooling. and the tooling parts that merge into the upper.

5.2.3 Sketches

In the initial sketching phase, as depicted in (Figure 39), a plethora of ideas were generated, all of which were either related to natural elements or constructions that require no adhesive. Of particular interest were shells and bird nests. This exploratory phase was intentionally unrestrained by any limitations and did not adhere to the moodboard.

In the second phase of sketching, a clear connection was established with the moodboard, as evident from figure 40. This phase aimed to advance one's ideas and explore various options, and the sock's structure had already been taken into consideration.

Incorporating the moodboard the main research question: “How to design a sneaker with a more sustainable construction technique that does not rely on glue?” and the Puma archive shoe, the third phase of sketching showcases the development of the final concept idea, as depicted in figure 41.

The ultimate design concept of the shoe is depicted in the subsequent Figures figure 42, 43, 44, 45.

Figure 39. First sketch Ideas

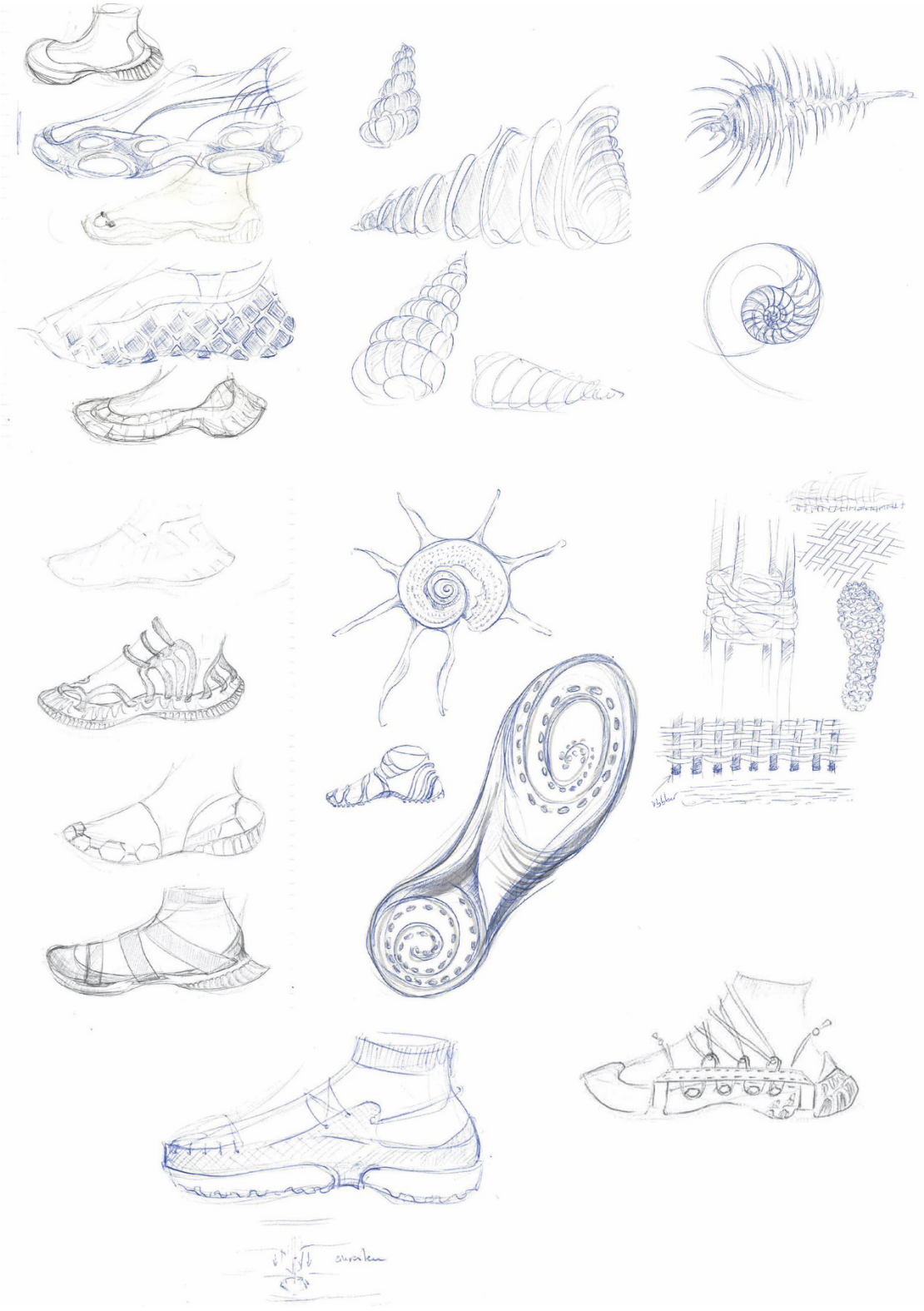


Figure 40. First sketch Ideas

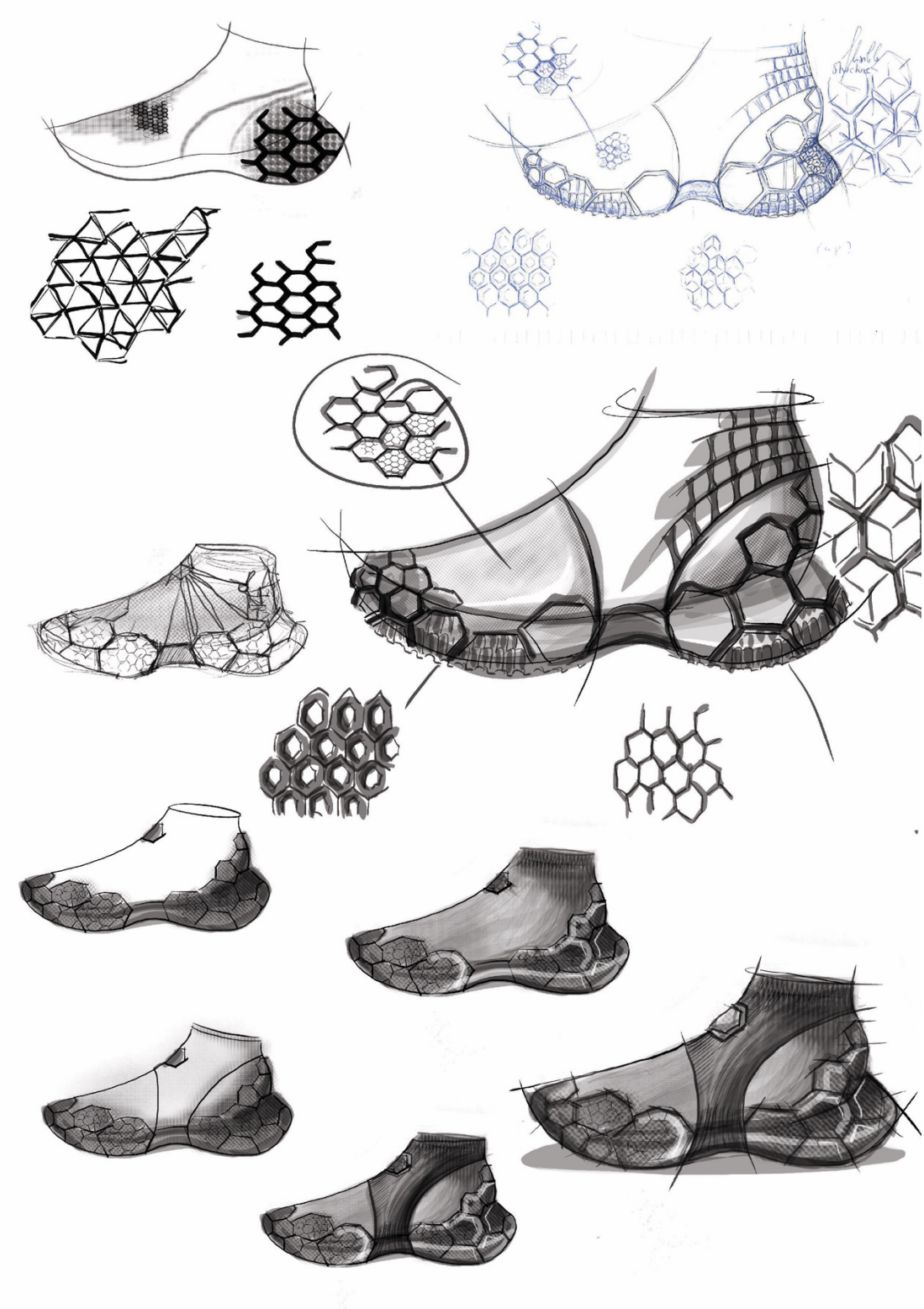


Figure 41. First sketch Ideas of final concept

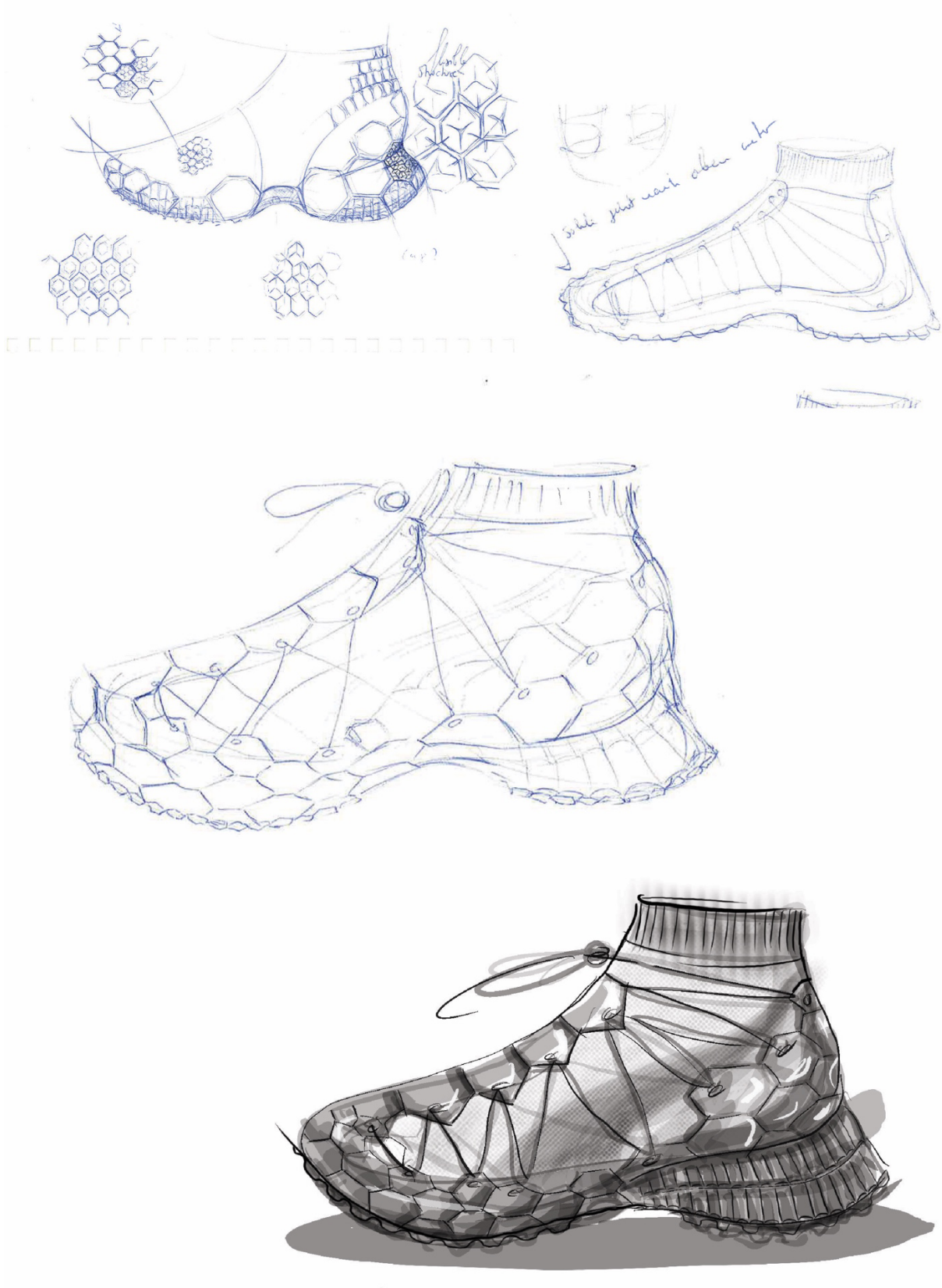


Figure 42. Final concept sketches

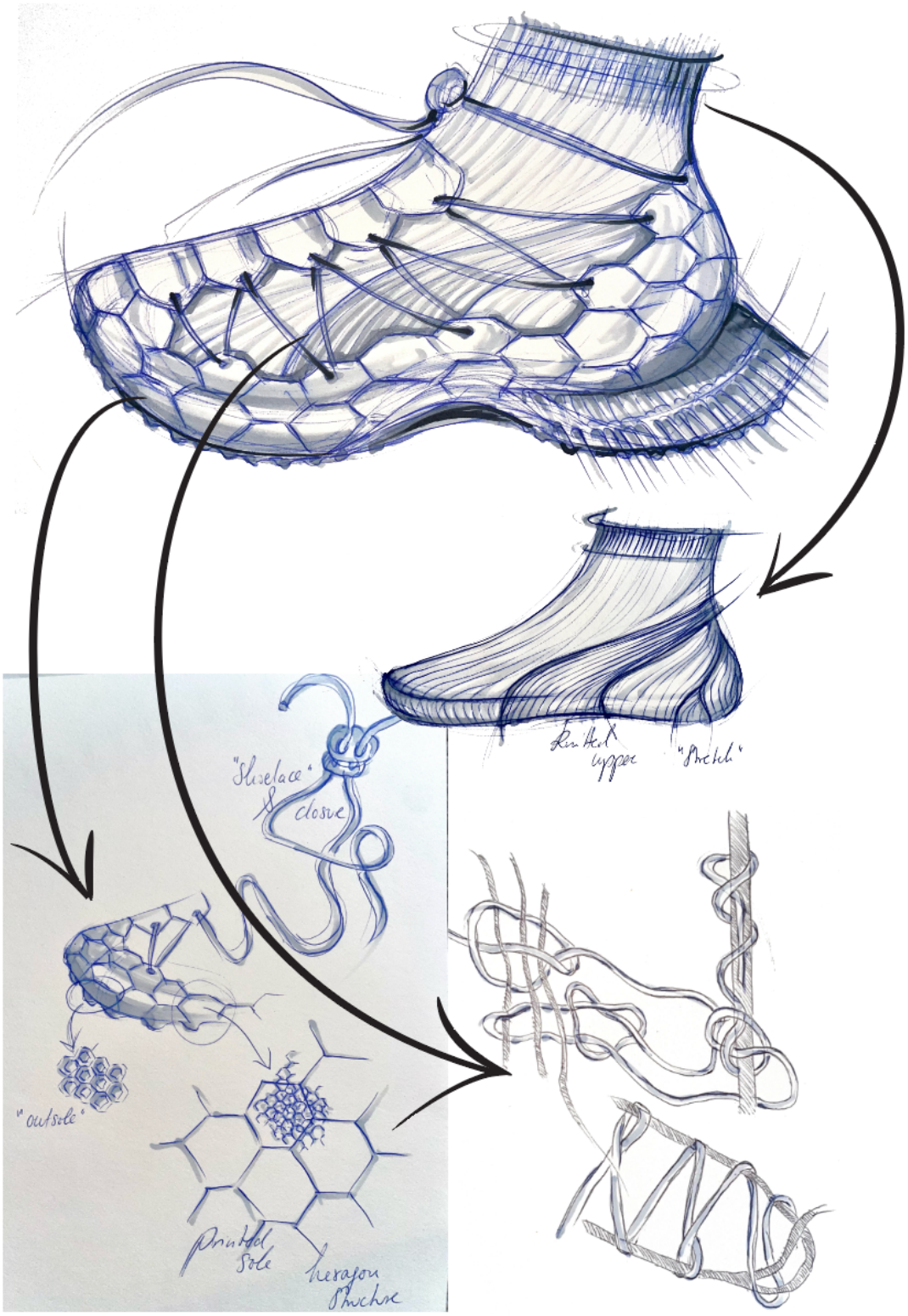


Figure 43. Final concept sketches

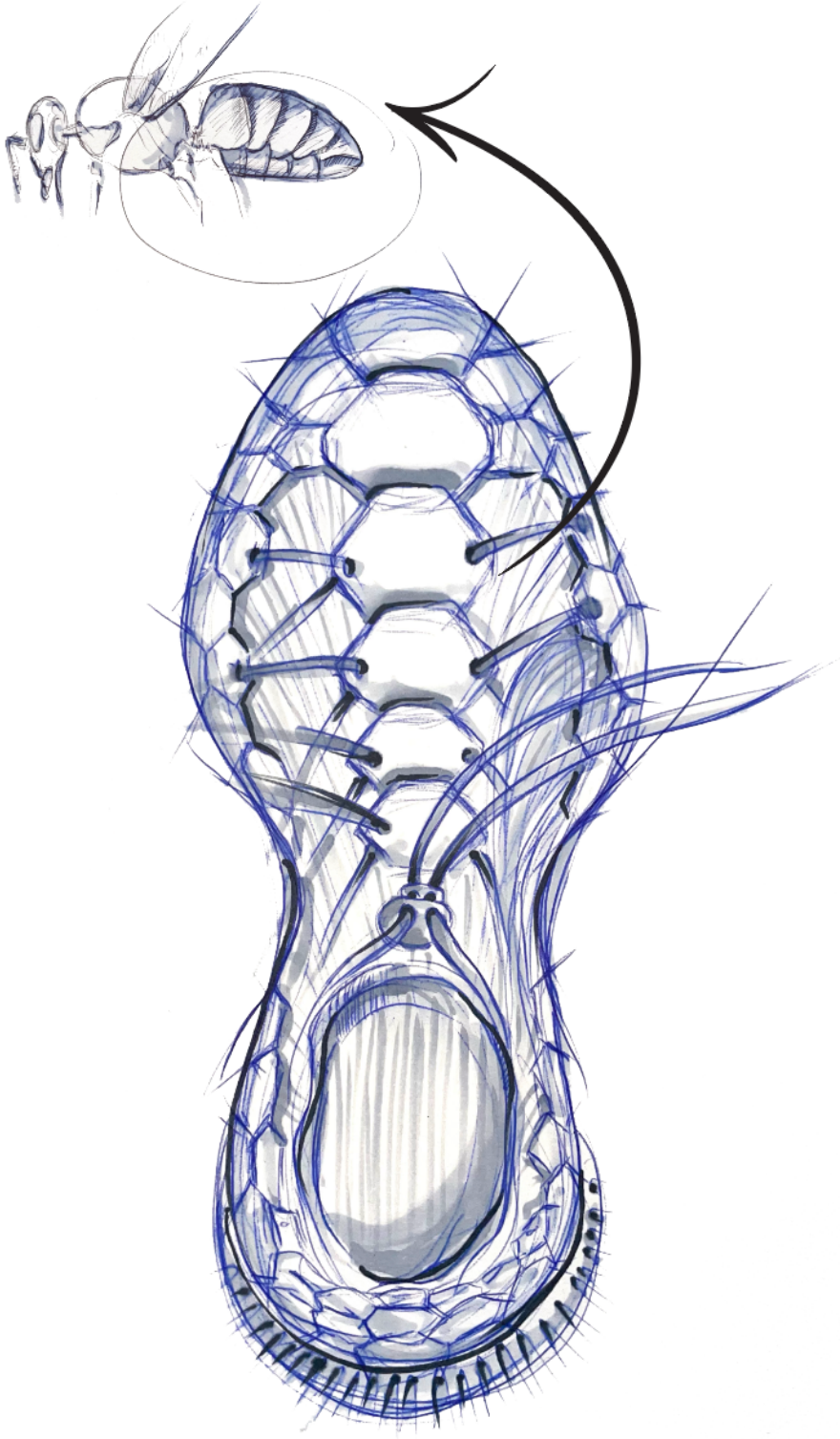


Figure 44. Final concept sketches

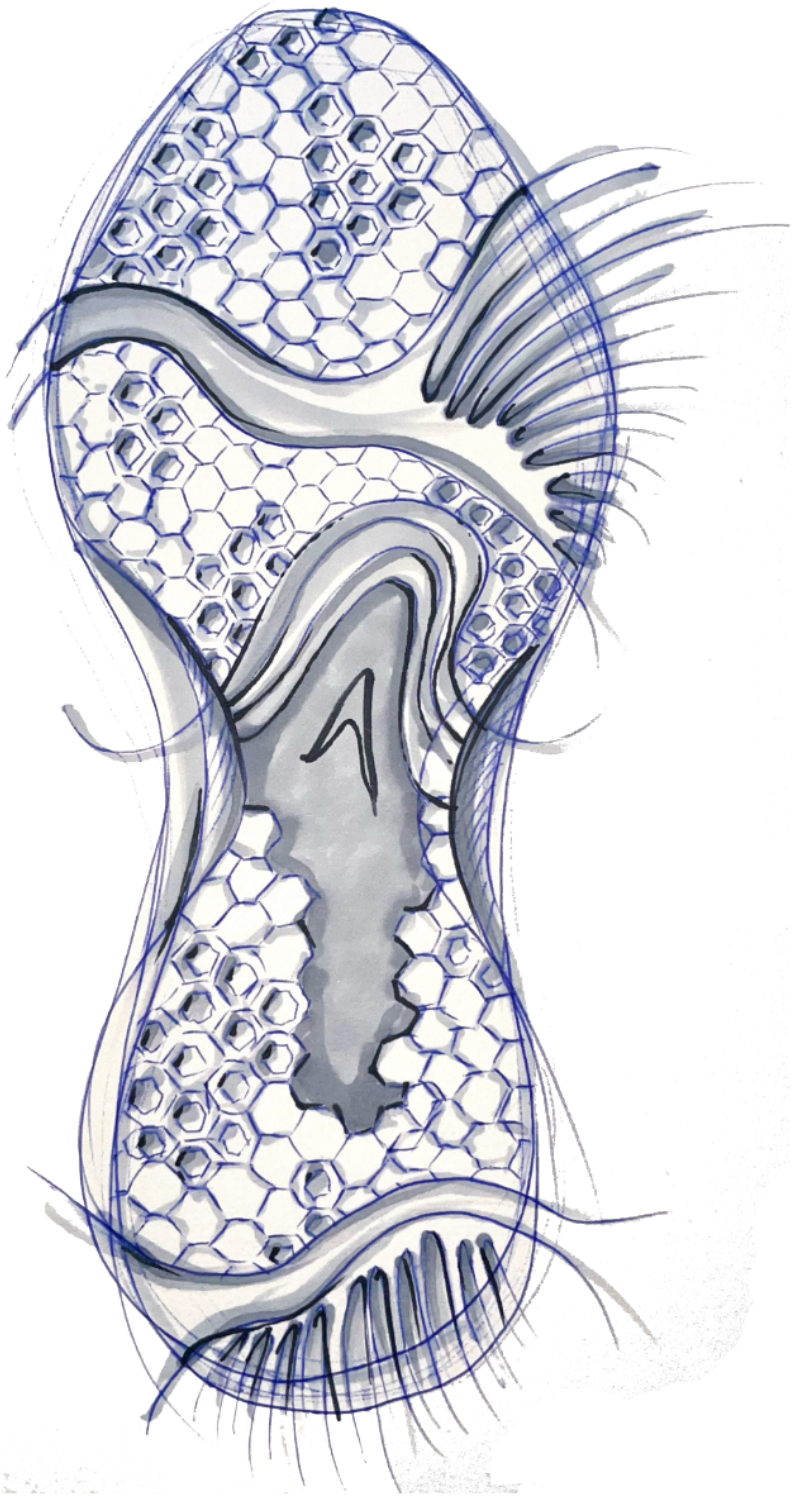
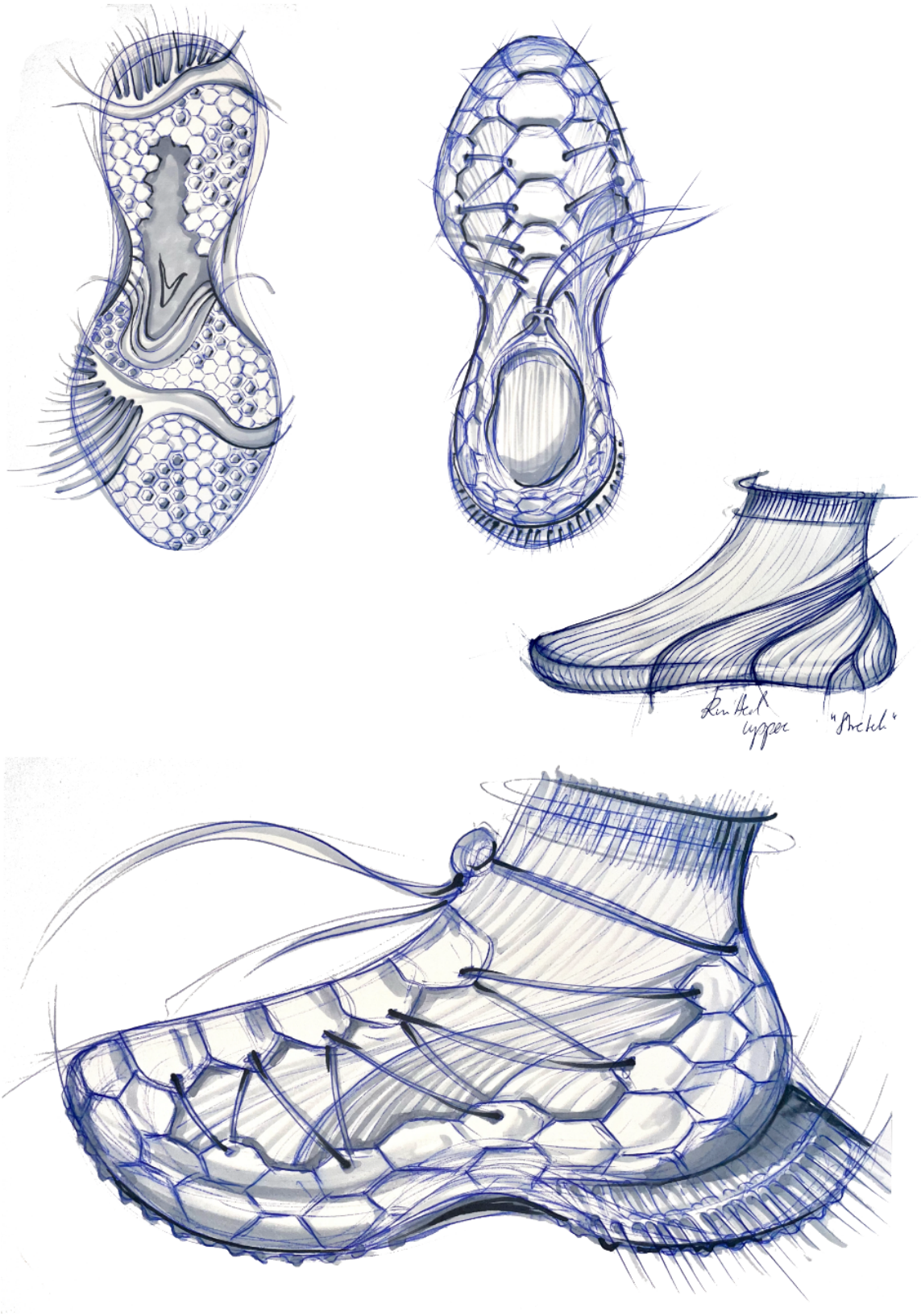


Figure 45. Final concept sketches



The proposed thesis concept is a unique sneaker design that incorporates a knitted sock with a Puma Formstripe branding on the medial side. The sock is made of elastic material with various line structures to provide proper support. The outsole is a single 4D-printed piece with complex forms that cover both the heel and the toe for maximum comfort and stability. The upper part of the shoe mimics the body of a wasp, allowing for necessary flexibility and a clothing system. The shoe's sole is inspired by the structure of bee honeycombs and wasp housing, with hexagonal pieces providing the necessary grip. The shoe is held together with a lacing system and is glue-free, making it easy to disassemble. Further testing and refinement will be done through mock-ups and prototypes.

Overall, the concept aims to offer a unique and innovative design that provides both comfort and stability. The incorporation of natural structures in the shoe's design is an interesting and unconventional approach that could potentially appeal to consumers interested in eco-friendly and sustainable products. Additionally, the easy disassembly of the shoe allows for easy repair and replacement of parts and is easy to recycle adding to the shoe's overall sustainability.

6 SUMMARY AND REFLECTION

“Design can only succeed if guided by an ethical view.”

John Vasson (n.d.)

This thesis aimed to address the research question of how to design a more sustainable sneaker construction technique that does not rely on glue. The research process involved exploring the current construction methods of sneakers and identifying the need for glue in footwear. The unsustainability of adhesives in shoe production was also examined. The study then delved into biomimetic design, seeking inspiration from nature to develop a sustainable sneaker design. Through an analysis of various sneaker brands and a study of a Puma archive sneaker, the research developed a concept for a sustainable sneaker design, using critical thinking and AI for further inspiration.

The contribution of this thesis is its proposed concept for a sustainable sneaker design that moves beyond simply using sustainable materials. By eliminating the use of glue and exploring biomimicry, the proposed design offers a more holistic approach that considers the entire manufacturing process and the shoe's afterlife, facilitating its recycling by disassembling it into its constituent parts and materials. While the proposed design represents a step towards a more sustainable footwear industry, further research into biomimicry is needed to fully realize its potential. Nonetheless, this thesis offers a valuable direction for designers to pursue in their own work, as good design should always solve a problem, and sustainable design is essential to creating a more responsible and environmentally conscious industry.

To explore this idea in greater depth, a potential approach would be to develop a modular sneaker that offers adaptability and customization options to users. The sneaker could be designed with interchangeable parts, enabling it to be used in various weather conditions, offering a higher level of versatility and convenience. In addition, exploring different materials could also be a viable approach to consider, as this thesis primarily focuses on the shoe's structure, but the selection of materials is equally critical to the overall design.

During the research process, the author has developed a keen interest in sustainable design. However, the author acknowledges that this exploration is only the beginning and sees this work as a steppingstone for further exploration. This work serves as a starting point for the author's personal journey into the field of sustainable design. Reflecting on this project, the author has realized the importance of incorporating biomimicry into their approach to develop even more effective and innovative designs inspired by nature. In future projects, the author intends to utilize biomimicry as a guiding principle to create sustainable designs that mimic nature's efficient and sustainable processes.

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Annex 1: Material management plan

Collection of data

The data for this study was collected from written sources.