Design of an outdoor lighting system for Slamp S.p.A.

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Master Thesis
MSc. Integrated Product Design
Faculty of Industrial Design Engineering Delft University of Technology
August 2020

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Executive Summary

Slamp spa is an Italian company, so far known for the design and production of decorative handmade lamps and lighting systems. Most of their current products are intended for indoor use. However, their plan for the coming years is to expand its portfolio with products also intended for external use.

Due to the generality of the topic, extensive research was carried out in order to narrow down the issue. The outdoor lamp market, trends, materials, and the production possibilities of Slamp were carefully analyzed. Interviews with users of outdoor lighting were also conducted. The analysis resulted in the selection of private use, portable lamps as a category for the designed product. The first stage of the project was summarized by defining the target group, personas, and scenarios.

The concept development stage was carried out. It was characterized by a large amount of generating ideas through simultaneously trial and error method, searching for the form, function, and proper operation of light. It was a process that combines the features of a structured, methodological approach to the work of the IDE and the work of an artist searching for inspiration by continuous experimentation. The stage was completed with the evaluation of the best concepts and the selection of the one, which was then subjected to further development and embodiment design.

The result was a wireless lamp designed for indoor and outdoor use. The product directly responds to the needs of the interviewed users who emphasized that despite the installed external lighting, they used additional light sources such as candles, LED lamps, lanterns, etc. The lamp's purpose is not to fully illuminate, but rather to provide additional or intimate illumination of the surroundings and a space in which the users are located. The lamps allow them to tune the mood and atmosphere, especially in a garden, on a terrace or a balcony. Furthermore, there is full freedom of how to use the lamp. It can stand horizontally, vertically, on the side, however users want, depending on their needs. It is recommended to buy not one, but two or three lamps to achieve optimal flexibility and optimal space illumination possibilities.

Double Diamond

During the project, the Double Diamond framework was used. Launched by Design Council's in 2004, the model provides a clear, visual description of the design process. The diamond shape of the framework represents the process of exploring the issue more widely (divergent thinking) or deeply (convergent thinking). The model divides the design process into four main phases: Discover, Define, Develop, Deliver. [1]

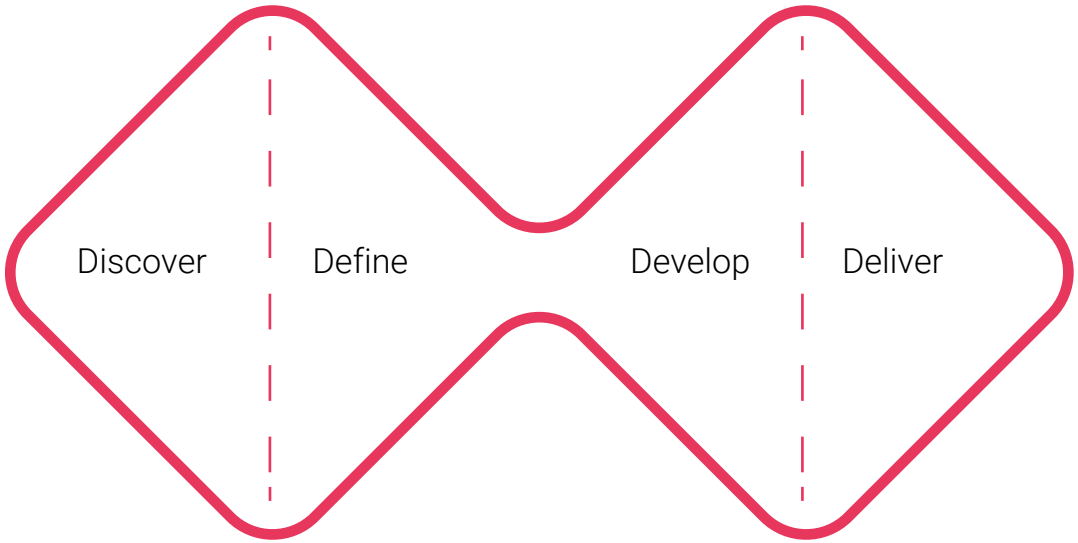

Figure 1: Representation of Double Diamond Approach

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Introduction

SLAMP spa founded in 1994 is famous for producing decorative, handmade lamps that combine creative use of unique materials and newest trends. The common elements of all the company's products are their values: visionary, adaptable, sensual, mysterious, innovative, accessible, reliable, aspirational, original, resourceful, experimental, suggestive and handmade. Each year, 55 thousand, handcrafted lamps produced by SLAMP is distributed to 108 countries around the world. Their young R&D team consists of 16 designers, architects, and engineers. Moreover, SLAMP cooperates with internationally-renowned designers and architects like Daniel Libeskind or Zaha Hadid which makes their products original and recognizable. SLAMP's products have been repeatedly awarded with prizes such as the RED DOT award.

SLAMP has been always focusing on interior lighting, however, their goal for next year is to introduce new collections of external lighting systems. This step seems to be a big event and a great change for a company with such traditions. The outdoor collection system, should combine SLAMP's values and design approach. Similar to their indoor lighting collections, SLAMP wants to focus on the innovative use of materials to make their product stand out. This can be through creative applications of current materials or use of groundbreaking emerging materials, alternative to current products and opens up new possibilities to inspire original applications and solutions.

Subsequently, SLAMP owns very advanced production resources. On 8 thousand square meters of manufacturing space, they can shape the various type of technopolymers into many decorative forms. However, it is possible to adapt their production methods and open for new, materials. Additionally, SLAMP distinguishes itself from others by using cold-cutting and hand-folding techniques to convert a two-dimensional sheet into a three-dimensional shape.

Lastly, the lighting system doesn't mean designing tangible product itself only. SLAMP's products stand out not only by appearance. Great lighting design makes their lamps extraordinary. Even an ordinary lamp can acquire additional values after turning it on. However, outdoor lighting systems have some limitations. For instance, bad lighting design shouldn't cause light pollution which can have a harmful impact on humans and the environment. That is why designing the lighting can be crucial for the final effect.

Reserach Phase

The research phase is the most important element of the design process. In this phase, the direction in which the project will follow is shaped. What's more, it is also a phase of discovering and acquiring the knowledge necessary for concept development. Finally, It is the stage of making key decisions having a huge impact on the final result of the project.

Due to the wide assignment and the variety of strategies for tackling the topic, many paths were taken to search for inspiration and expand knowledge in the fields of light, innovative materials, market research, and more.

The purpose of this stage was to determine the direction of the project and to specify the category of light that will be designed. The ultimate goal of the stage was also determining the target group, personas, and product usage scenarios.

Brief Historical Context of Artificial Lighting

The story of artificial lighting started when, for the first time, someone came up with an idea to separate the burning branches from the source of warmth and use it for a specific purpose. After this discovery, the advantages of separated light sources became obvious. Through the years, the branches were replaced by resinous pinewood, and then a flammable material was applied on the wood to produce more light artificially.

The great achievement was the development of the oil lamp and the candle. Thanks to that, people obtained the lighting source, which is rather compact and certainly safer than previous developments. Because the wick (the means of transport for oil or wax) replaced the torch holder, fuels were used much more economically. However, compared to the modern days, the luminous power of either candle or the oil lamps was very poor. The flame was restricted to its direct environment. Household gathered around a source of light that illuminates only a small space around. To illuminate the interior, it was necessary to have a large number of complicated lamps and accessories. [2]

The situation changed at the end of the 18th century. In 1784 the Swiss engineer Aime Argand applied the patent for the lamp, which was later named after him, Argand lamp. Thanks to the improved oxygen supply and enlarger wick surface, luminous efficiency was significantly upgraded. Subsequently, a glass cylinder was mounted around a wick and a flame. Due to the increased throughput of air, The chimney' caused a further increase in lamps' efficiency and performance.

In 1772, William Murdoch used coal gas for lighting his private house in Redruth, which was the first commercial use of gaslighting. However, the first person who patented coal gas lighting in 1804 was Friedrich Winzer, a German inventor. At the beginning of the 19th century, gaslights were present in the biggest cities in Europe and the United States. [3]

In 1801, Sir Humphrey Davy invented the first electric carbon arc lamp. A carbon arc lamp works thanks to the connection of two carbon rods to a source of electricity.

In 1860 Joseph Swan invented and later on, in 1879, Thomas Edison succeeded in developing, mass product the incandescent light bulb, definitely one of humanity's greatest discoveries. Compared to the light sources that existed at that time, it was a huge improvement. [3]

In 1927, Friedrich Meyer, Hans Spanner, and Edmund Germer invented a fluorescent lamp. Comparing a new invention to the mercury vapor, thanks to the inside coating, fluorescent lamps are much more efficient. [4]

In the 20th century, the most popular were high-intensity discharge (HID) lamps like fluorescent lamps, mercury vapor, high-pressure sodium, or metal halide. All these lamps are based on a similar kind of technology. They operate thanks to an electrical current sent between two metal electrodes and a glass tube filled with inert gas. This operation results in the emission of visible light. [5]

The invention that was significantly different from previous lighting achievements was the Light Emitting Diode (LED) invention. LED technology, like none of the traditional bulbs, does not require glass housing, and it works by converting electrical current using a semiconductor. Throughout the 20th century, many scientists have influenced the development of this technology. [4] Already in 1907, Henry Joseph Round observed this phenomenon in Silicon Carbide. In 1962, Nick Holonyak (General Electric) invented the first LED, which could produce visible red light. The real breakthrough in this technology took place in 1994. Shuji Nakamura invented the ultra-bright blue LEDs and later on high-intensity blue and green LEDs. The discovery was the foundation for the incredibly functional LEDs that are currently known. [6]

Light Introduction

Attributes of Light

There are many reasons why we use light. Nowadays, people are not content with only the primitive and distinct light function, which is illuminating the darkness. When the era of electric light came, the light was easier to control. People have learned how to manipulate light so that they can perform specific tasks. For instance, architectural lighting gives people the ability to emphasize the essential details of facades. Thanks to the appropriate use of light, people can enjoy spaces during the night hours. We use light to reshape and fill empty spaces in interiors, as well as exteriors.

Lighting systems also have secondary functions. Apart from the light's primary purpose, lighting systems or lamps itself can also be design items that are focal points of interiors and give character to spaces. People use lamps not only to lighten the spaces but also to furnish them. Moreover, lamps express peoples' tastes. Thanks to that, lights are the tools to personalize spaces.

Lastly, light impacts our quality of life. By changing light qualities, it is possible to affect the atmosphere. By setting suitable lighting, it is possible to impact peoples' perception of comfort. [7]

Outdoor Lighting

However, the project focuses on external light. Compared to indoor lamps and lighting systems apart from a few exceptions, outdoor lamps are not a focal point in the garden, more to illuminate, accentuate objects in the garden (trees, paths, art pieces, facades, etc). Furthermore, a lamp to be used outside must be explicitly recommended for the outdoor. It must be resistant to moisture, atmospheric agents, thermal shocks, and UV rays. Often people don't have a ceiling and four walls. Therefore people are looking for different anchor points to attach the lamps. Sometimes, the wish is to bring outside the same mood as the indoor furnishing style and lighting.

Lighting Categorization

Lighting can be divided into four main categories: technology based, function and its contribution, appearance, as well as, atmosphere. Technology based rely on lighting technology that each lighting system uses, for instance incandescent lamps, LEDs etc. Function based, for example way-finding and navigation lights, architectural lighting to accentuate the features and elements of the space, walls, floors etc., or task lighting to illuminates work areas like desk. Appearance contributes to ambient, focus or brilliance layer etc. However, atmosphere lighting affects the atmosphere perceived in a given space like cosy, romantic, detached etc.

Impact of Artificial Light

Artificial Light at Night (ALAN)

For a billion years, life on earth lived in the rhythm of a clear division between day and night. Nowadays, this border is usually blurred. Artificial light illuminates the city's darkness and makes the cities glow at night. It disturbs the natural day-night rhythm and unfortunately, has a negative impact on the environment. The effects of excessive lighting at night may seem marginal, but more and more sources and experts indicate clearly - excessive artificial light at night (ALAN) has adverse effects such as:

- Harming human health
- Increasing energy consumption
- Disturbing the ecosystem and wildlife [8]

The lighting pollution is obtrusive artificial light, which brightens the natural lighting conditions. There are three main effects of ALAN, which are disturbing [9]:

- Glare - excessive brightness that causes visual discomfort
- Light trespass - light is falling on the places where is not intended or needed
- Skyglow - brightening of the night sky over inhabited areas
- Clutter - confusing and excessive groupings of light sources

How bad is it? According to the "World Atlas of Artificial Night Sky Brightness," 80 percent of humans population lives under skyglow. However, in Europe and the United States, 99 percent of people can't experience natural skyglow.

Figure 2: The lighting pollution

Impact on Humans

Like animals and plants, humans have become accustomed to the natural day-night cycle for millions of years of evolution. As studies show, this natural cycle disorder can increase obesity, depression, sleep disorders, diabetes, etc.

Like most of life on earth, people are dependent on circadian rhythm. This is the so-called biological clock - natural information when to go to sleep and when to get up according to the day-night cycle. Artificial light can disturb this cycle.

One of the most important hormones that the human body produces is melatonin. Thanks to its antioxidant properties, it encourages the immune system, induces sleep, lowers cholesterol, etc. In short, thanks to it, people are

healthy. Unfortunately, nighttime exposure to artificial light limits the production of melatonin.

Especially, exposure to blue light is dangerous. As it turns out, many LED lights used for outdoor and indoor lighting, TV, computer, and smartphone screens produce blue light. As a result, although new technologies like LEDs are more energy-saving, which is theoretically less harmful to the environment, it can have adverse effects directly on human health. Moreover, traditional incandescent bulbs were less energy-efficient but produced less blue light than LEDs.

In 2016, the American Medical Association issued light temperature recommendations that should be used in LED bulbs. They suggested a light temperature not exceeding 3000K. [9]

Impact on Wildlife

Like humans, animals are also affected by light. It triggers certain behaviors, impacts their sleep-wake cycles, and gives a signal when it is safe to migrate, reproduce, eat, and sleep.

When artificial lighting began to be widely used, certain natural behaviors that evolved over millions of years were disturbed. ALAN confuses some animals and makes them vulnerable to predation, exhaustion, injury. Sometimes their productivity is decreased or dramatically, dangerously increased.

According to Doug Hitchcox, a naturalist at Main Audubon, and Sarah Haggerty, conservation biologist, light affects animals in various ways. For instance, some animals are disoriented and can mistake artificial lights for moonlight. Electrical lights favor diurnal species and can lead to conflict between them and their nocturnal equivalents. However, in some cases, nocturnal species, which are evolved to hide, are hurt by a problem of predation because they are more likely to get eaten. Additionally, artificial lighting can cause animals and insects to fly into buildings and other obstacles. Animals can breed inefficiently and avoid common hunting and roosting areas. Furthermore, the “24-hour lifestyle” can inhibit their growth. [10]

According to Franz Hölker [11] over 60% of invertebrates and 30% vertebrate organisms inhabit the nightscape and have fine-tuned senses, adapted to the nighttime environment. Light pollution can interfere with their circadian, seasonal behavior and disrupt ecosystems.

Furthermore, as a new study suggests, artificial lighting can harm interactions between herbivores and pollinators. Disturbing seasonal light cues can cause an imbalance in taming with herbivores and suppressing flowing in wild species. [11]

To reduce the harmful impact of artificial outdoor lighting on nature Doug Hitchcox and Sarah Haggerty suggest using outdoor lighting fixtures. They are angled downward, have proper shielding to avoid skyglow, and are far enough from reflective surfaces, such as decorative items. Additionally, they advise using a light temperature of 3000K or lower and are low-watt or low-lumen to avoid harsh shadows. [10]

Impact on Plants

It is generally known that light is essential to plants' life. By chloroplast, they can gather sunlight. Through a series of chemical reactions, in a process called photosynthesis, solar energy is converted into glucose, " the usable energy." Because (with few exceptions) plants are the type of organisms that can transform solar energy directly into the production of their own "food," it would be quite logical to think that ALAN doesn't affect plants negatively. However, this is not true. [12]

According to a study of Maja Grubisic of the Leibniz-Institute of Freshwater Ecology and Inland Fisheries and colleagues, lighting pollution actually can discourage the growth of periphyton - microscopic plant communities. [13] Additionally, LED lighting at night hurts larger plants like some grass species. [14]

Light pollution can impact negatively because the light is also the source of information. "trees living near street lamps that had retained some of their leaves longer than normal was one of the earliest observations of the effects of light pollution on plants." [12]

The fate of plants is also closely related to the fate of pollinators. When pollinators such as insects, moths, baths, are disoriented or distracted by ALAN, plants don't get nighttime pollination, which contributes to the limited production of seeds and destructive impact on the whole ecosystem. [10]

Figure 3: Impact of lighting pollution on plants

Psychology of Light

Impact of Colors

There are three main qualities of light related to color - **brightness, hue and saturation.** Researchers proved that brighter light can intensify emotions, while low light keeps them steady. It means that people can make more rational decisions and find it easier to agree in negotiations in low light. [15]

Hue is defined as a color or shade while saturation is the intensity of a color. More saturated colors can amplify emotions, while muted ones can dampen emotions.

Color temperature is the definition of the warmness or coolness of light sources. Colors like red, orange, and yellow are considered as warm colors, and influence people psychologically to feel warm. Colors like blue or green are considered as a cool colors and make people feel relaxed. The scale of color temperatures is based on correlated color temperature - CCT. [16]

Figure 4: The color temperature scale

Cool colors make people energetic, and thanks to the fact that blue light suppresses melatonin levels, it can interrupt people's sleep patterns. Brain cells tend to be much more sensitive to blue wavelengths and the least to warm ones. Due to this fact, warm colors - lower temperature lights are least likely to impact our internal sleep clock. Better sleep improves people's cognition and overall mental wellbeing. [15]

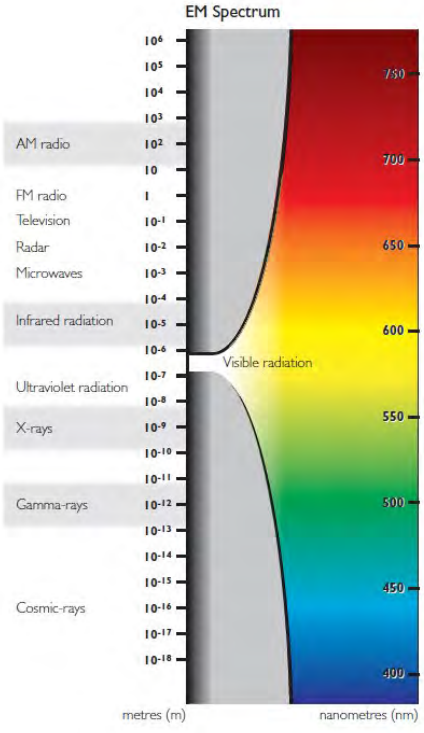


Figure 5: EM Spectrum

Direction of Light

Another important element is a light direction. By changing a light direction, it is possible to transform spaces and impact the way of how people feel in spaces. [15]

PSYCHOLOGICAL IMPACT	LIGHTING EFFECT	LIGHT DISTRIBUTION
Tense	Intense direct light from above.	Non-uniform
Relaxed	Lower overhead lighting with some lighting at room perimeter, warm color tones.	Non-uniform
Work/Visual Clarity	Bright light on work-plane with less light at the perimeter, wall lighting, cooler color tones.	Uniform
Spaciousness	Bright light with lighting on walls and possibly ceiling.	Uniform
Privacy/Intimacy	Low light level at activity space with a little perimeter lighting and dark areas in rest of space.	Non-uniform

Content retrieved from IES Light Logic (www.ieslightlogic.com)

Figure 6: The influence of various lighting effects on the sensation

Impact on Mood and Behavior

Light affects people's mood, behavior, and well-being. Researches proved that people's negative and positive emotions under intense light are heightened. Additionally, light has an impact on our appetite. Dim lighting in exclusive restaurants can make people eat slower, while bright lights can make people eat more unhealthy. It is because bright lights make people happier and don't pay much attention to calories. Furthermore, bright interiors make people eat faster, while dim interiors relax. [17]

Figure 7

Impact on Atmosphere

Researchers proved that light can be used to change an atmosphere of a room. Interestingly, this is not only about extreme color and spatial distribution differences. Even gentle change in color temperature and intensity have great impact on perceived atmosphere. [18]

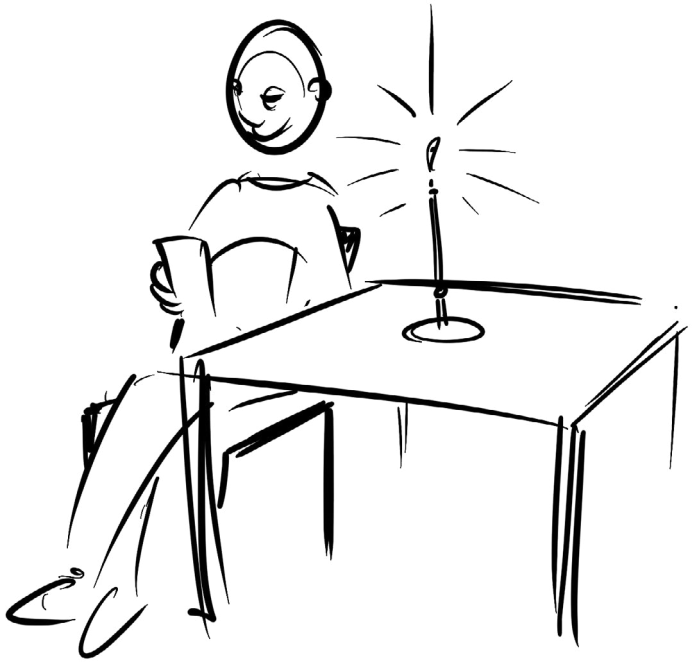


Figure 8

Slamp's production techniques

SLAMP spa founded in 1994 is famous for producing decorative, handmade lamps that combine creative use of unique materials and newest trends. Each year, 55 thousand, handcrafted lamps produced by SLAMP is distributed to 108 countries around the world.

According to Slamp, their lamps are unique and recognizable thanks to technopolymers. This type of material is characterized by special nobility, lightweight, UV, and heat resistance, as well as, high strength. Additional value is the fact that technopolymers can be shaped into various decorative forms. In Slamp's portfolio, the manner of transforming two-dimensional sheets into three-dimensional shapes is visible. Slamp process these materials by methods like cold-cutting or hand-folding. [19]

Figure 9 : Manual finalization of Slamp products

Figure 10: Cold-cutting process

Another advantage of technopolymers is the fact that these materials can be tinted in various ways. This method uses non-toxic, UV-resistant, Greenguard certified ink. The big benefit of this technique is that the light is not blocked by pigmentation. Another interesting effect which Slamp is able to achieve with their technopolymers is iridescent polarization. Thanks to this process, technopolymers achieve the look of ‚freshly formed soap bubbles'.

Slamp takes care of sustainability. They claim that the materials used in the manufacturing of their products are completely reusable and recyclable. Thanks to cold industrial manufacturing, harmful substances are not emitted to the atmosphere. Technopolymers are durable, so the product lifespan is extremely good.

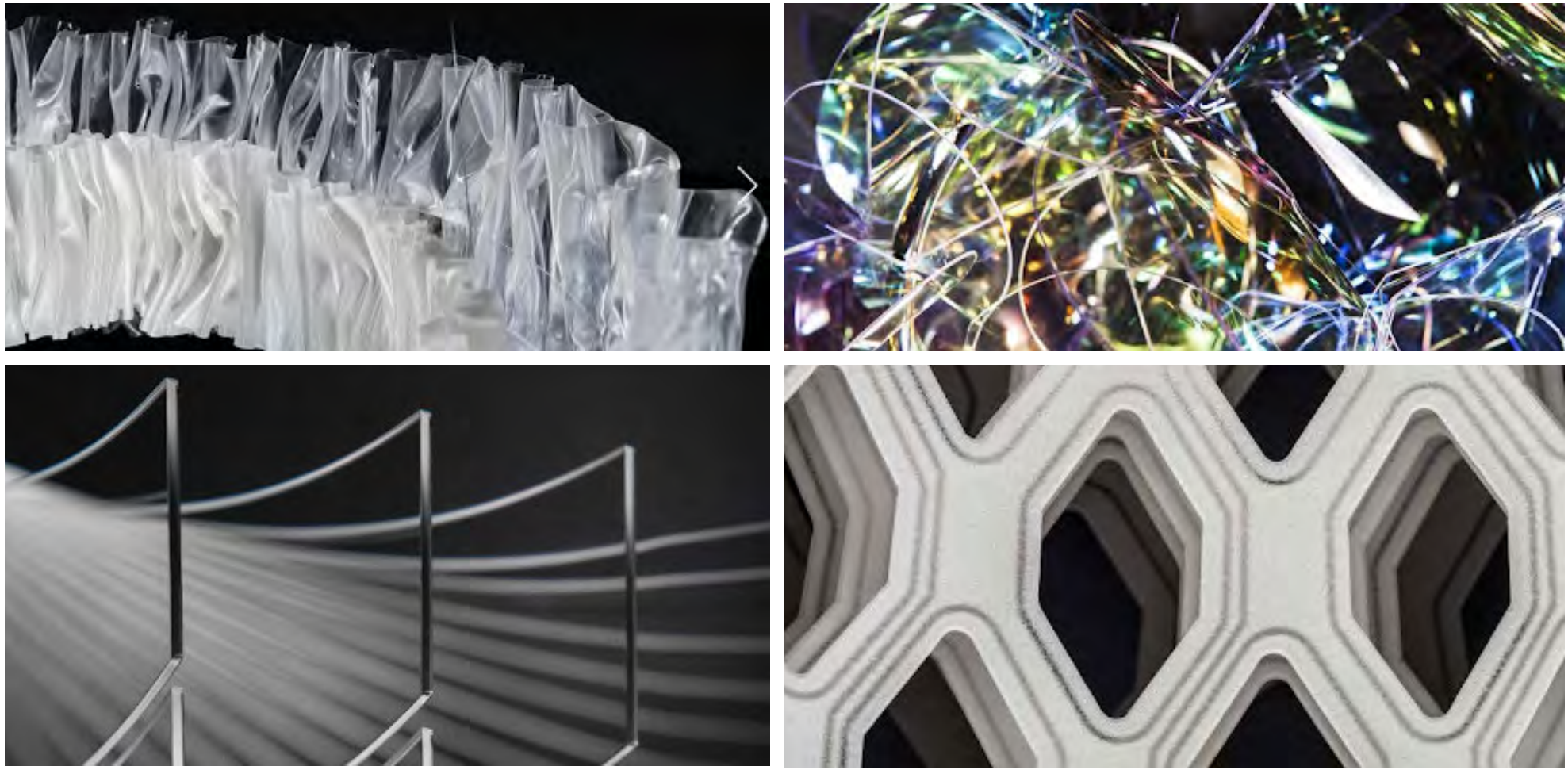


Figure 11: Effects obtained through the manufacturing processes of Slamp

Material research

To look for materials that can be an interesting alternative to materials currently used by Slamp and innovative materials that can be a source of inspiration for further work, extensive research was carried out. The research relied on a subjective selection of materials, for instance, more sustainable ones than those currently used, materials that can be processed by methods currently used by Slamp, interesting light diffusers and others. Production locations of the material were also taken into account. Emphasis was placed on materials produced in Italy or the near distance.

In this research, it was decided to skip 'obvious' materials and focus on unusual and extraordinary ones.

Ecopixel

Ecopixel from Italy is a material, which is 100% industrial waste made of Low-Density Polyethylene (LDPE). Ecopixel is recyclable, recycled, circular, and sustainable. It can be melted and re-melted an infinite number of times. Furthermore, the material is light, translucent, and hygienic. It is also suitable for indoor and outdoor use. It resists temperatures from -10°C to +50°C.

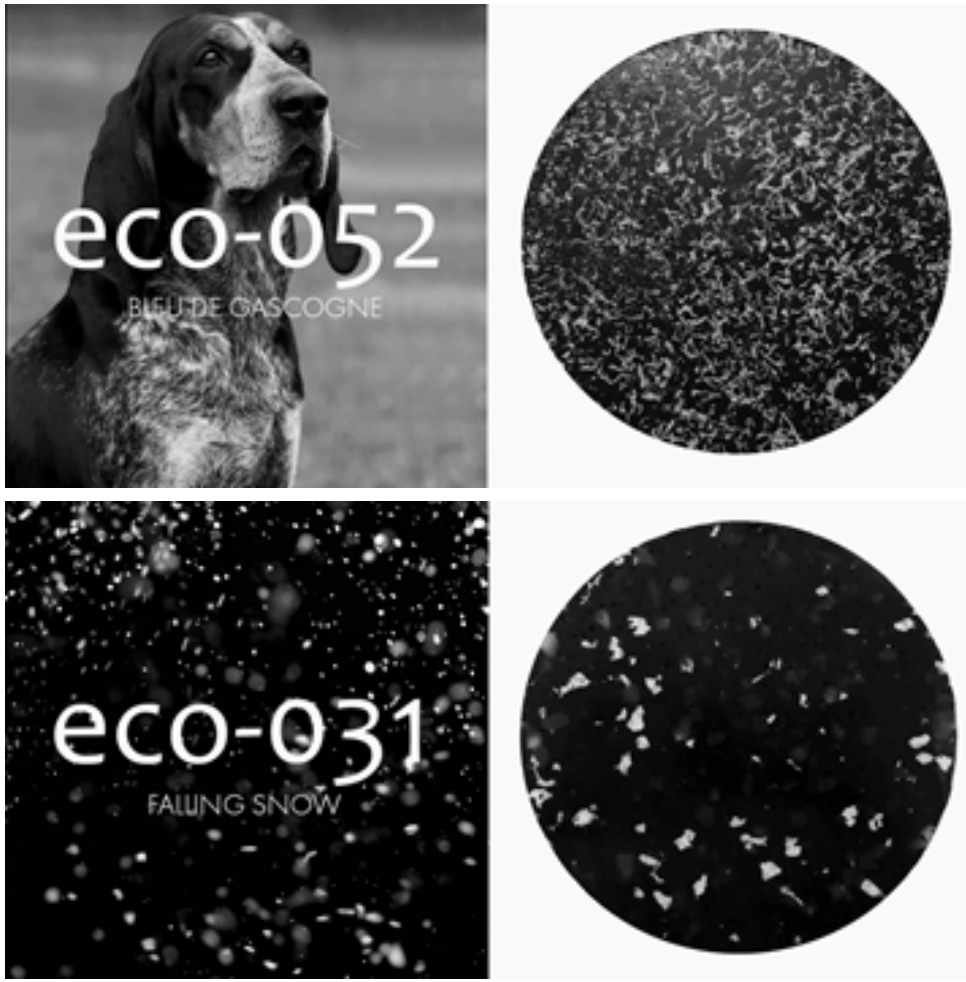


Figure 12: Examples of Ecopixel patterns

Karuun

Karuun, by Out for Space from Germany, is unique, remarkable, and innovative material. Karuun is basically rattan tubes which are injected by bulking agents. It is non-fiber material, which means that it is a great, natural alternative to plastic. An interesting feature of the Karuun is that depending on the direction in which it is cut, three different products with different possibilities are achieved.

Figure 13: Karrun samples

Viber

Viber is a 100% biodegradable starch-based biopolymer from the Netherlands. Consisting of natural wood ingredients (lignin and cellulose) has similar mechanical and thermal properties as natural, grown wood. Importantly, the material can be processed by several methods characteristic of average plastics like injection molding, blow molding, thermoforming, or extrusion.

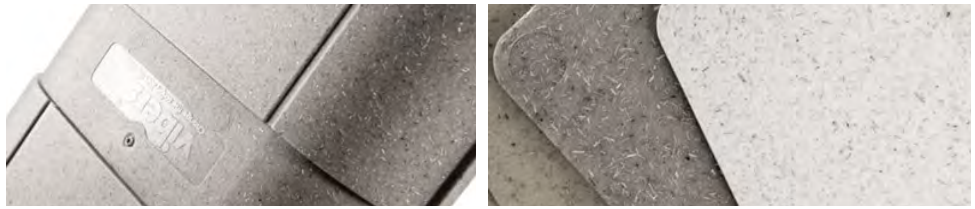


Figure 14: Viber samples

Prism Commodities

Jungbecker Optics from Germany, introduced a series of light guiding optical sheets, called Prism Commodities. They released various of options like Conical De-glaring Prism, Light Guiding Prismatic Plate, Asymmetrical De-glaring Prism and more. The material has good weather resistance, however is not renewable.

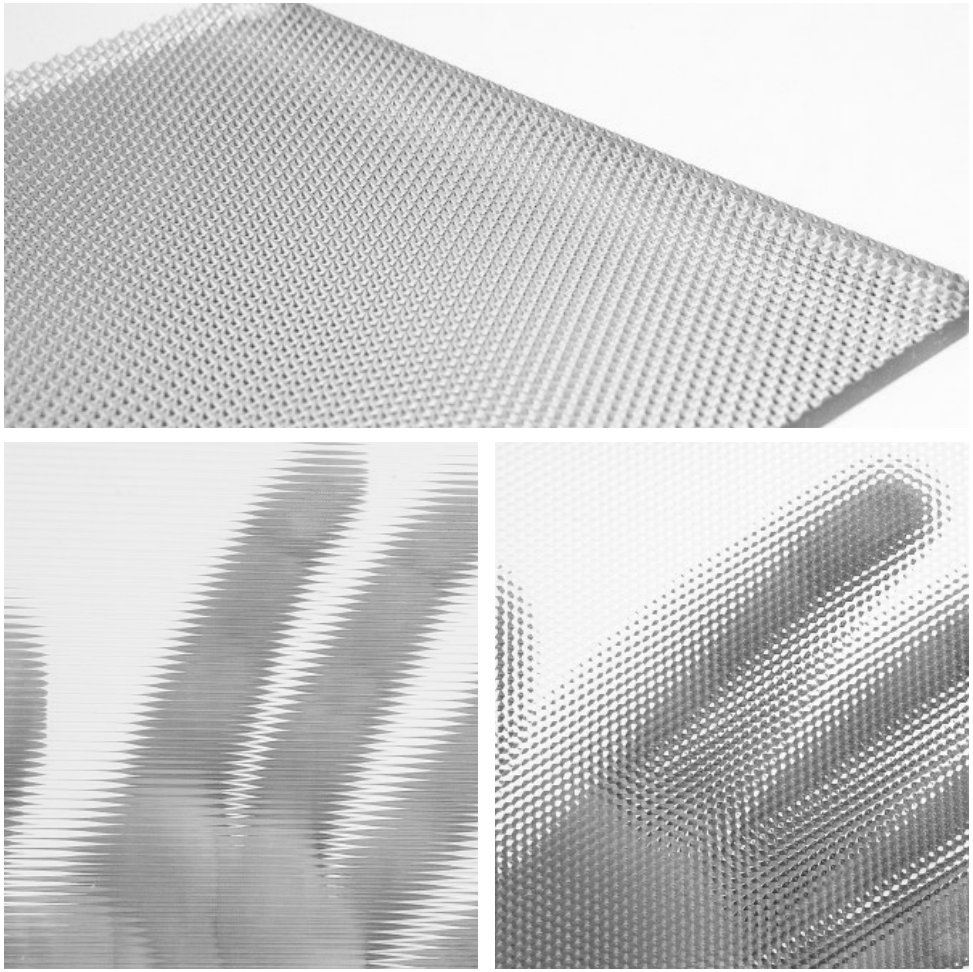


Figure 15: Prism samples

Trend analysis

According to the Kjaer Global, there are for main trends for 2020 that shape digital technology: **Smart – Social – Organic – Wellness.** [20]

However, shortly after the analysis has begun, it was recognized that it is more beneficial for this project to focus on searching for unique, fresh lighting products or product concepts and lighting technologies than on searching for general global trends. Regularly happens that this kind of innovative products often become trend markers in specific categories and are replicated by larger companies.

The pictures below depict a subjective compilation of interesting projects with high potential. Mainly websites such as Tradehunter, Global Influences, Yanko Design, or Behance were searched.

The Bolita Illuminator

Design studio Kaschkasch's to underline the importance of human touch, especially during a digital age, designed an illuminator that has to be moved manually to control the light. As the designers describe, „Bolita seeks out that user interaction." [21]

Figure 16: Bolita by Kaschkasch Studio

Angel Ring

The Angel Ring is designed in order to help new mums feed their children during the night. The ring can be worn on mum's arm, thank to which mum has two hands-free. [22]

Figure 17: The Angel Ring

The Tinge

Series of Lamps by Jacob Starkley have simple hands-on interaction. You can control the brightness of the lamp simply by rotating the gradient disc - black on one side, transparent on another. [23]

Figure 18: The Tinge by Jacob Starkley

Quetzal Lamp

The lamp by Marc Venot for Missana invites the user to interact with it. The lamp has dual-colored individual paper members, which allows the user to dim the light or make a great pattern against the walls and the floor. [24]

Figure 19: Quetzal lamp by Marc Venot

Doolight

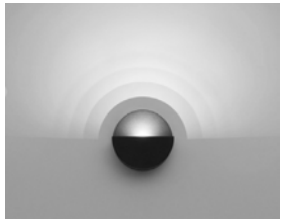
Doolight by Doosan Baek is an innovative chandelier consisting of multiple hanging lights, that could be detached at any time carried around. [25]

Figure 20: Doolight by Doosan Baek

Market analysis

After a discussion with the Slamp Spa representatives, it was concluded that, considering the products currently produced by Slamp, their style and characteristics, focus will be narrowed down to private use outdoor lighting.

To obtain information on lighting products intended for external use, a comprehensive market analysis was carried out. Examples of private use, outdoor lighting products of companies whose Slamp could become a potential competitor were collected and grouped. As a result, products potentially interesting as a design direction for Slamp, were divided into 10 categories:



wall lamps

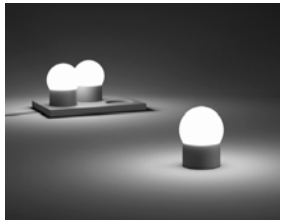
ceiling lamps

floor lamps

bollard lamps

pendant lamps

garden lamp posts



outdoor table lamps

lanterns

step lights

outdoor spotlights

The products have been divided into styling oriented (focus on aesthetics and decorations) and function-oriented like step light or spotlights. Then, considering the Slamp portfolio, their existing products, and values, styling oriented products, were selected.

Together with a Slamp company representative, it was found that outdoor table lamps and lanterns are particularly interesting. This step definitely means a smooth transition for Slamp (between what they do now and outdoor lighting they want to introduce) because lamps from these two categories are often used both outside and inside. Furthermore, a wide range of applications, not only for gardens, but also for balconies, terraces, and commercial use like restaurants. Also, interviews showed a need for a convenient light source, that makes the atmosphere as well as provide additional light

It was finally agreed to choose wireless, portable lamps, but not limited to table lamps or lanterns, but to think more broadly about portability and its possibilities.

Interview

Stage 1

To find out if/how/when people use outdoor lighting and what are their motivations or problems and concerns, the remote interview was conducted. Twelve gardens/terraces/balconies owners were interviewed. The age range of participants was between 25 and 72 years old.

The interview was divided into two phases. The first part intended to acquire general knowledge about the intentions of people regarding external lighting. The general questions were asked, such as:

- Do you have Garden/ Terrace/ Balcony?
- Do you use outdoor lighting?
- If yes, what kind of outdoor lighting do you use?
- Why do you use this kind of lighting? What do you want to achieve by using these lamps?
- If you have a lighting system, did you assemble it yourself?
- Is something irritating in your outdoor lighting system? Would you like to change something?

This part resulted in gathering general information, which was already known: people use garden lights to accentuate interesting parts/elements of the garden to create a nice atmosphere, safety reasons, or just to spend night hours outside. Additionally, the insights on specific outdoor lighting products, which can be used at further stages of the project, were collected.

Figure 21: Selected answers of Stage 1

Stage 2

The second stage turned out to be more advantageous. Participants were asked to imagine the following situation:

"Now imagine, there is a warm summer evening, your friends/ family are coming, and you want to spend night hours outside."

Then the following questions were asked:

- Where do you spend this evening?
- Is it a place where you do it always, or you change the locations?
- Do you use some additional (not fixed) lighting to illuminate the place where you sit?
- Why do you use this thing specifically?
- Is there something extremely annoying when using this product?
- Would you change something in this
- product?

Surprisingly, people with gardens and terrace, regardless of age, often change the location of spending time outdoors. If they have a large terrace, they move from one zone to another, depending on the mood. If they have a terrace and garden, they also migrate from the terrace to the garden during the evenings. Additionally, balconies owners complained about the poor quality of light on the balcony. Most importantly, even though people possess advanced external lighting systems, they use additional sources of light like candles, lanterns, wide range of LED lights, 'Chinese Lamps,' etc. All these sources of light are used to create a nice atmosphere, intimacy, or illuminate table that often is not bright enough.

For all the answers, see Appendix A.

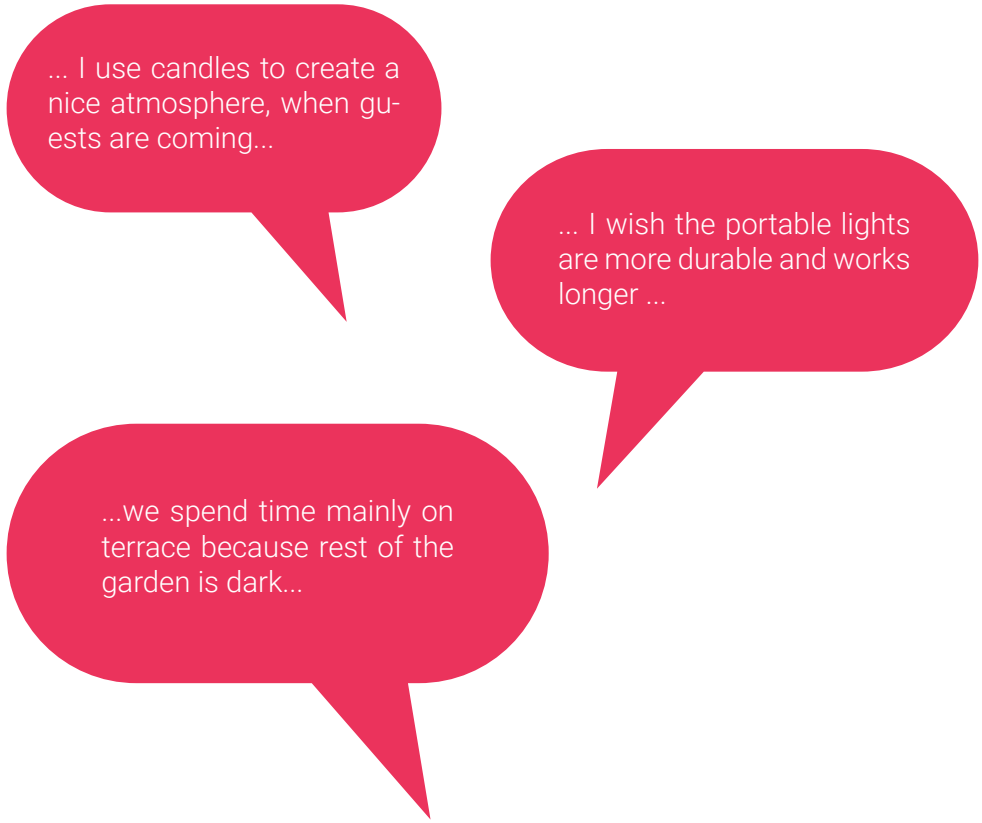


Figure 22: Selected answers of Stage 2

Target Group

To determine the target group for the designed product, the photographs from the Slamp website were initially analyzed. Slamp has a wide database with interior images in which it advertises its products. With this information, it is possible to determine their clients' age range, status, income, and basic characteristics.

The collages with photos of Slamp products in the interiors in which they advertise them, were created:

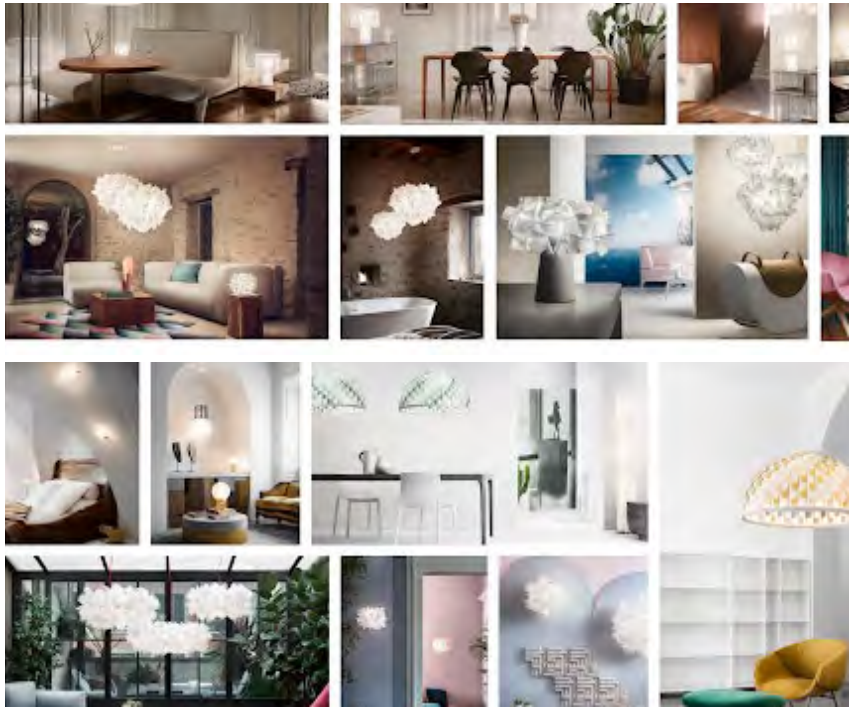


Figure 23: Slamp interiors

The next step was to create collages from photos of gardens, terraces, and balconies, which style matches the interiors in which Slamp advertises their lamps. Thanks to this action, a better idea about people living in these spaces, was obtained. After careful analysis and consultation with Slamp authorities, the target group characteristic was determined:

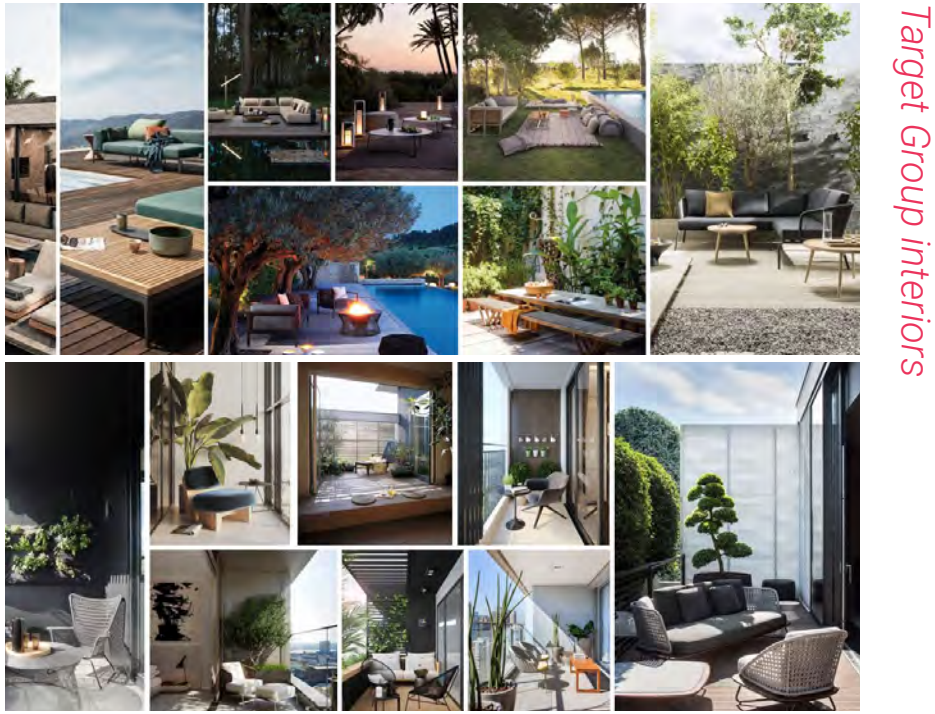


Figure 24: Target group interiors

The findings were summarized in a target group statement:

Our ideal customers are 40-50 y/o, middle-income house/apartment owners with access to a garden, terrace, or balcony. Ideally, they are in a stable stage of life; they have life partners, even children. The target group enjoys high quality, handmade products, and is not afraid of innovativeness/technology. They live in modern, trendy houses. Their lifestyle can be characterized as active and social. In their leisure time, they love to spend their time outdoors.

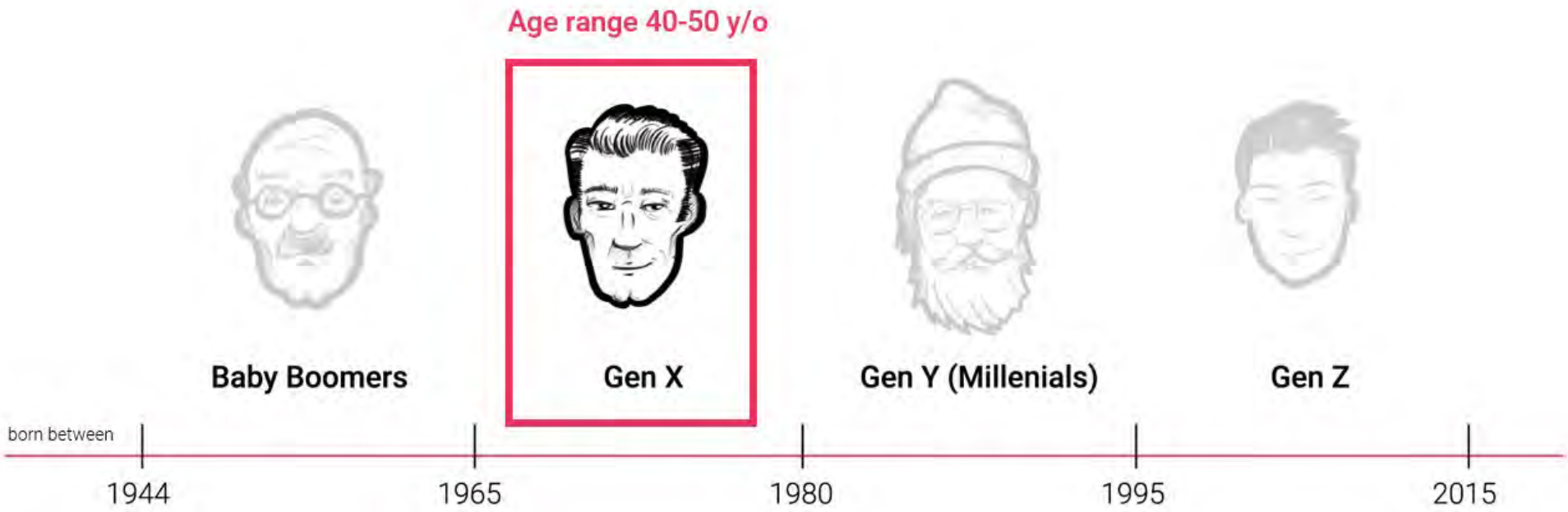


Figure 25: Visualization of generations

Personas

For a better understanding of the target group and for a clear overview of people for whom the product is intended, it was decided to create Personas [26]. **Based on the information gained before, two separate personas were created - 46 y/o Mario and 42 y/o Eva.** Both fit the middle-income target group, and they live in Western Europe. It was important to highlight their characters' differences and other ways to spend their leisure time.

Personas also differs by their homes. Mario lives in an apartment in Milan, while Eva resides house in Malaga, Spain.

Finally, photos of fictitious interiors and exteriors of their homes were added. The photos fit both their characters and interiors in which Slamp advertise their products.

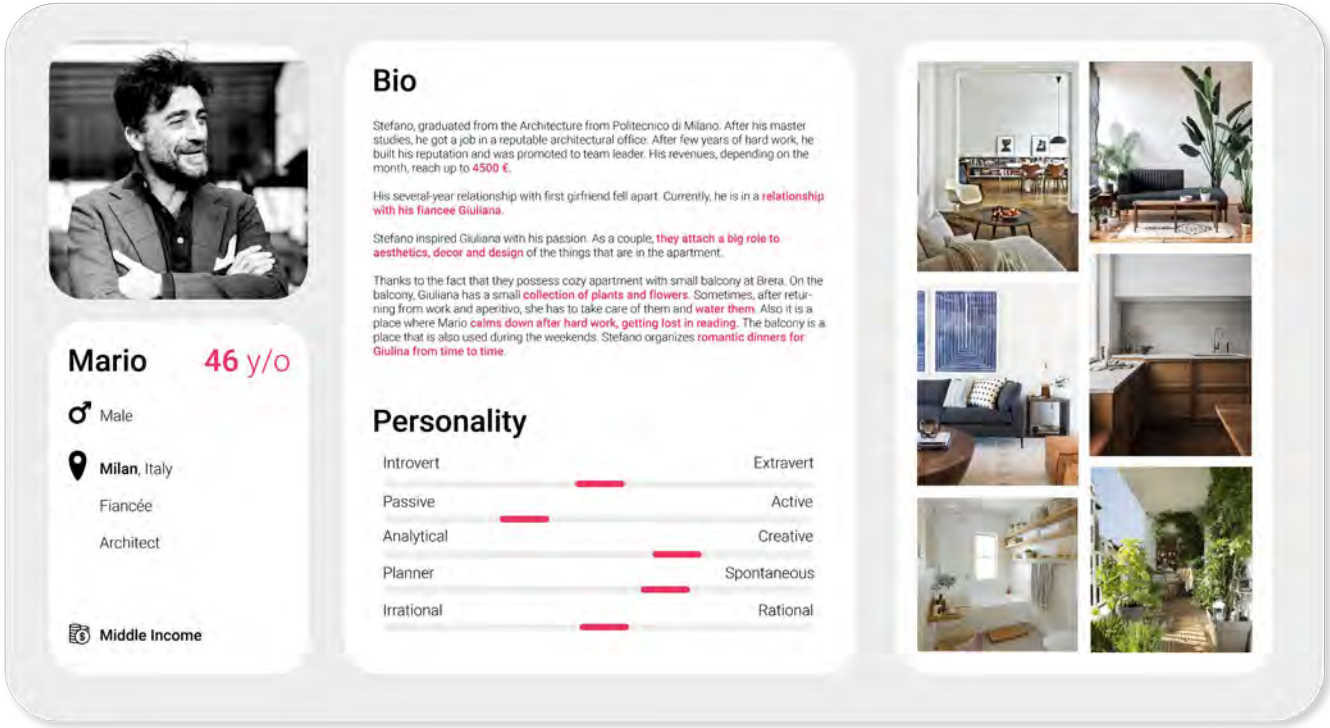


Figure 26: Representation of Mario

Ana 42 y/o

♂ Female

Malaga, Spain

Husband

Two kids

Bank Manager

Middle Income

Bio

Ana graduated form the Barcelona School of Economics. After graduation, she easily got a job at one of the Catalan banks. For several years, she was climbing the career path until she met her future husband, the engineer from Andalusia. Exhausted with years of corporate work, she decided to change the environment and move with him to Malaga.

She got new job, they bought small but beautiful house near the beach. After their wedding, two beautiful children were born to them. Thanks to the fact that Eva found the job at Santander bank in Malaga, her salary is 4,000 € a month.

In their modern but slightly rustic property, they have a **beautiful garden and a terrace**. From time to time, on weekends their family and friends visit. In the days and **evenings they spend a lot of time outdoors**. They cook **Paella and drink Vino Tinto Verano**. It happens, that during the week their friends visit with whom they **drink wine and eat tapas.**

However, Eva and Rafa sometimes need peace and relax after work. Then, they change the surroundings and **move to the garden**, where they **rest on a hammock, read books on sunbeds and watch the children playing in the pool.**

Personality

Introvert	Extravert
Passive	Active
Analytical	Creative
Planner	Spontaneous
Irrational	Rational

Figure 27: Representation of Ana

Scenarios

The final stage of the research phase is creating scenarios, which, together with the personas and target group, will form the basis for the next phases of the project. For this purpose, the list of evening activities that can be performed on the balcony, terrace, or garden, was created. Only activities that stereotypically could be performed by the selected target group were considered. The list was consulted with Slamp representatives, who also added their activities.

Garden:

Picnic
Reading book on the hammock
Garden Party
Swimming in the pool
Walking and talking on the phone

Terrace:

BBQ
Romantic dinner
Birthday party
Spending time at the pool
Cooking outside
Making pizza
Cocktail party
Reading book
Cooking Paella
Aperitivo / el Aperitivo

Balcony:

Smoking cigarettes
Drinking wine
Reading book
Romantic dinner
Balcony party
Playing with kids
Watering plants

To previously determined personas, a subjective choice of scenarios that fit Mario and Ana's characters, was made. Besides, to each of the scenarios was added atmosphere characteristics that prevail during the scenario and small activities that make up the scenario.

Mario's scenarios:

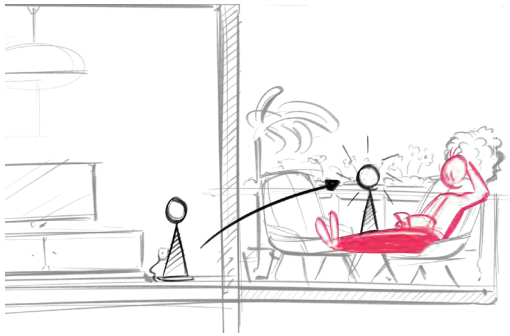
Watering Plants

Atmosphere:

- Calm
- Patient
- Relaxed

Activities:

- Watering the plants
- Checking if everything is alright



Leisure Time

Atmosphere:

- Peaceful
- Cozy
- Calm
- Restful

Activities:

- Reading book
- Drinking
- Having snack
- Having nap

Romantic Dinner

Atmosphere:

- Romantic
- Charming
- Peaceful
- Erotic
- Quite
- Intimate

Activities:

- Eating
- Drinking wine
- Looking into each other's eyes
- fooling around

Ana's scenarios:

Aperitivo / El Aperitivo

Atmosphere:

- Bustling
- Cheerful
- Loud
- Enthusiastic
- Joyful

Activities:

- Cooking Paella
- BBQ
- Eating
- Drinking
- Talking
- Singing

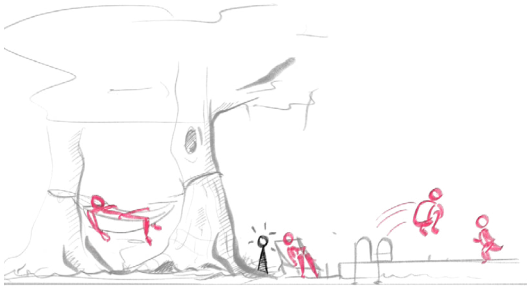
Intimate Evening with Friends

Atmosphere:

- Peaceful
- Pleasant
- Relaxed
- Enjoyable
- Lovely

Activities:

- Eating
- Drinking wine
- Talking
- Listen to the music



Resting in the Garden

Atmosphere:

- Peaceful
- Refreshing
- Cozy
- Calm
- Restful

Activities:

- Reading book
- Observing kids
- Having a nap
- Drinking soda

After the meeting with Slamp, three most interesting scenarios were selected: reading a book during the evening, romantic dinner, and aperitivo. Selected scenarios were supplemented with information on lighting qualities that should be used in a particular situation.

		Reading a Book	Romantic Dinner	Aperitivo
Scenarios characteristics	Scenario			
	Activities	reading book, drinking ,having snack, having nap	eating, drinking wine, looking into each other's eyes, fooling around	cooking Paella, making Pizza, BBQ, eating, drinking, talking, singing
	Atmosphere	relaxing, peaceful, cozy, calm, restful	romantic, charming, peacful, erotic, quite, intimate	bustling, cheerful, loud, enthusiastic, joyful
Lighting qualities	Light temperature	temperature that has a warm tone or a yellowish color, **around 3000 K,** If study cooler colors	**warm colors** - sunset, red orange hue, avois „cool" colors, **around 2000 K**	**around 3000-3500,** warmer light more intimate, cooler energetic
	Brightness (Intensity)	If your light is too bright or too dim, your reading will be hampered, older people require brighter lamps	**just enough to see the food,** use dimmers to turn down the lights (cozy fireplace, candles)	see people around and food, brighter than Romantic Dinner,
	Positionong	side light, rear light, even illumination of the book, the body doesn't cover the illumination	lighting from below - we are more attractive, low lighting creates more intimacy	**lighting higher** - we can see more aaacurately, table and food more visable, see environment
	Others		no hursh contrast, smooth transitions from light and dark, highliting effects - use objects that reflect light	

Figure 28: Representation of selected scenarios with lighting qualities

Research Summary

The research phase resulted in acquiring the necessary knowledge needed to continue work on the project. Among other things, informations were obtained regarding the properties of light and its impact on flora and fauna and people. An analysis of the market and lamp categories for outdoor use was carried out. Slamp's production capacity has also been explored. Moreover, an external lighting interview was conducted with potential Slamp customers.

Most importantly, however, the key decisions for the project were made. The category for the product being designed is set for **private outdoor use, portable light.**

The target group was also selected: **40-50 y/o, middle-income house/apartment owners with access to a garden, terrace, or balcony. Ideally, they are in a stable stage of life. They have life partners, even children. The target group enjoys high quality, handmade products, and is not afraid of innovativeness/technology. They live in modern, trendy houses. Their lifestyle can be characterized as active and social. In their leisure time, they love to spend their time outdoors.**

To visualize and understand the target group easier, **the following personas were created: Mario and Ana**. Finally, scenarios were created: **Reading a Book, Romantic Dinner, and Aperitivo. Scenarios were made along with the light properties that should be used in each of them.**

Concept Development

The consequence of the research phase of the project was setting the target group and personas, as well as product use scenarios. These findings were the so-called base for further design stages, and above all for the concept development phase.

As expected, the concept development phase of this particular project was not a typical, structured process in the traditional sense of IDE. Due to the specificity and uniqueness of Slamp, it was decided to adapt to the way the company works. Their work is based on constant experimenting, gathering inspirations from many sources like nature and fashion, playing with materials, light diffusers or light qualities, stepping back and going ahead. In other words, the process more often resembles the work of an artist than an organized designer. However, when designing a product like lamp, especially in the Slamp release - handmade, decorative art pieces, this action seems very reasonable. At subsequent stages of product development, each choice affects the other. If you change outer material, you need to change light diffuser, you change diffuser, you have to change lighting source etc. Often, it is necessary to take a step back to do two forwards.

The real challenge was to weave into this somewhat chaotic process the methods used at TU Delft and contained e.g. in the Delft Design Guide. However, at some moments these methods proved to be extremely helpful and even crucial for the whole project.

To facilitate understanding of the design process and the decisions that were taken at various stages, the concept development phase was presented as workflow.

Moodboards

In the beginning, wide research was carried out to find inspiration among existing products. The search did not focus only on lamps and light products but on ceramics, vases, interesting use of materials, colors, etc. The discoveries were grouped and divided into separate categories., for instance:

Shape

Material

Light

Interaction

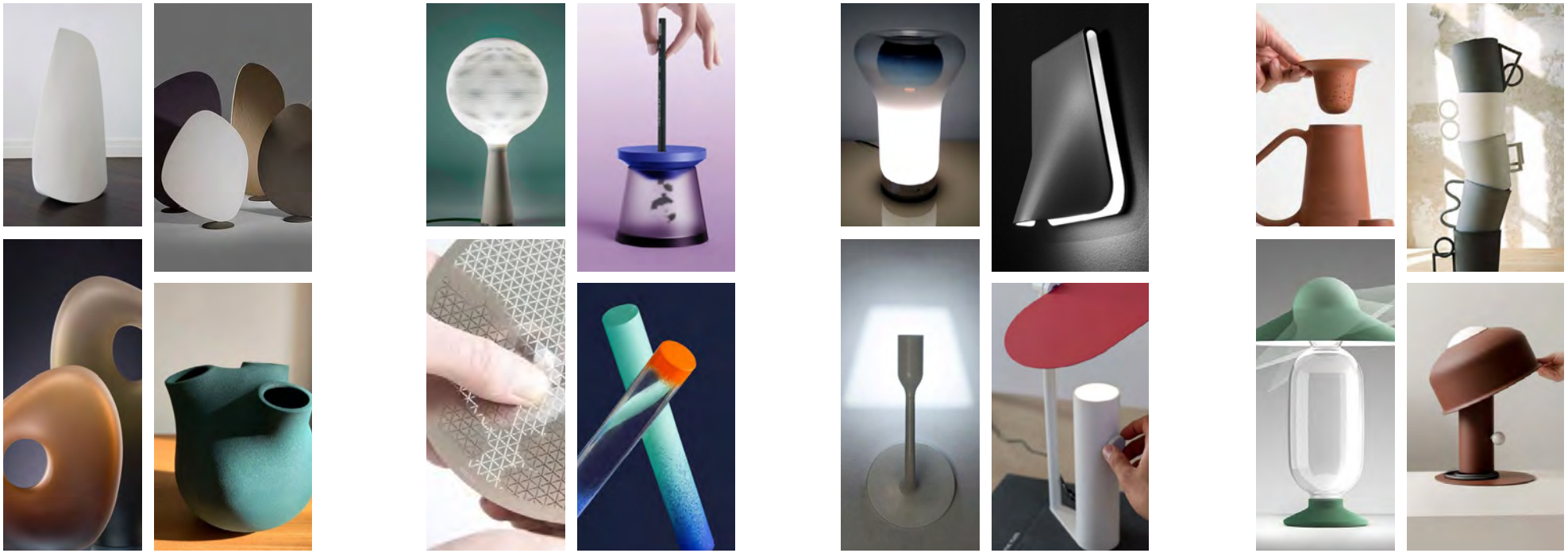


Figure 29: Examples of objects from the moodboards

Brainwriting & Brain Drawing

In parallel, to gather more information and ideas on how to solve selected problems and issues related to the project, the Brainwriting & Brain Drawing Method [26] was conducted. Due to current epidemiological conditions, it had to be done remotely using Zoom - Video Conferencing Software. Two external participants and the author of the project participated in the study. External contributors were introduced to the topic, scenarios, and target group, subsequently, they were presented with the following three questions:

- *How might we indicate that the product is easy to carry?*
- *How might we transit between scenarios? - Explanation: How might we change light qualities/shape/diffusers/direction of light in order to move from one scenario to another?*
- *How might we change light qualities?*

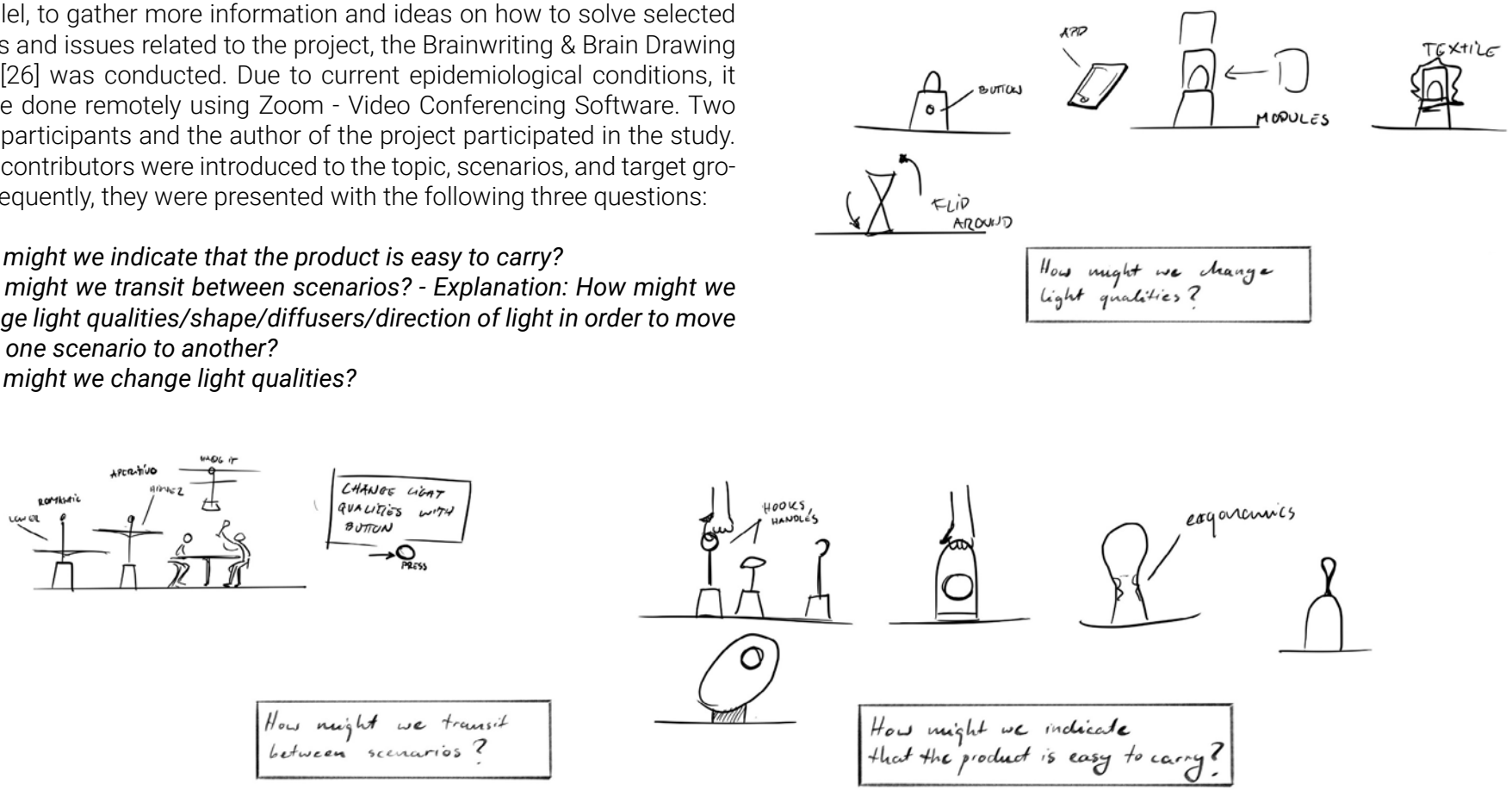


Figure 30: Scans of chosen drawings made by the participants

Exercises have resulted in the following ideas. To indicate that the product is easy to use, participants emphasized the importance of the product's ergonomy, suggesting that the product is movable. Also, there were voices that the product should give the impression of durable - nonfragile so that the user will feel free to move the object.

Answering the questions about the transit between the scenarios, there were suggestions of intelligent solutions sensing the change of the scenario, the environment, the number of people, thanks to which the properties of light would adapt to the demand. Simpler solutions were also presented. For example, transition by simple gestures such as turning the lamp from one side to the other - similarly to Eero Aarnio Trioli Chair or "modular construction which enables a user to have more scenarios."

Regarding the last question regarding the change of light properties, the participants proposed several similar solutions, as in the previous question. However, there were also solutions such as morphable material changing the direction and intensity of light.

Figure 31: Trioli Chair by Eero Aarnio

Concepts generation

After gathering initial inspirations and broad ideas, the time has come for the stage of creating and generating specific concepts. This stage began with creating many sketches but quickly evolved into the simultaneous generation of ideas on several abstraction levels. A simple sketch in a short time was processed in the 3Ds Max software, which in comparison to parametric programs such as SolidWorks or Creo, allows for more free and faster modeling. This is especially important in the early stages of generating ideas because this type of software does not limit the user's imagination. Furthermore, 3D modeling gives a much better picture of the designed product. It is devoid of „eye-catching" additions, making the drawn product look much better than the one without all extras. Along with drawings and 3d models, physical models were being created that more or less were reflecting the appearance, shape, proportions, and simplified interaction with the product in reality.

During the first two weeks, four concepts were created. They were simultaneously developed and then presented to representatives of the Slamp. This stage's primary goal was to generate ideas that could be used during all previously selected scenarios: Reading a Book, Romantic Dinner, Aperitivo.

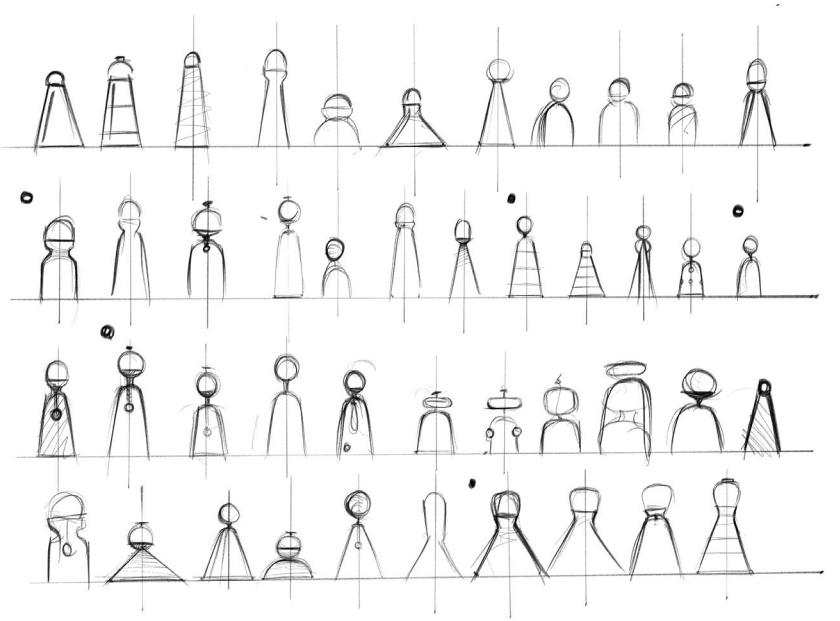


Figure 32: Sketches of one of the developed concepts

Concept A

The first idea resulted from a search for inspiration in nature. Inspired by the leaf, the lampshade is a surface reflecting light from the light source placed in the lower module. There is a circle at the top of the lamp, which indicates that the lamp is suitable for carrying, makes it easy to grab, and allows hanging the lamp from the ceiling or other object.

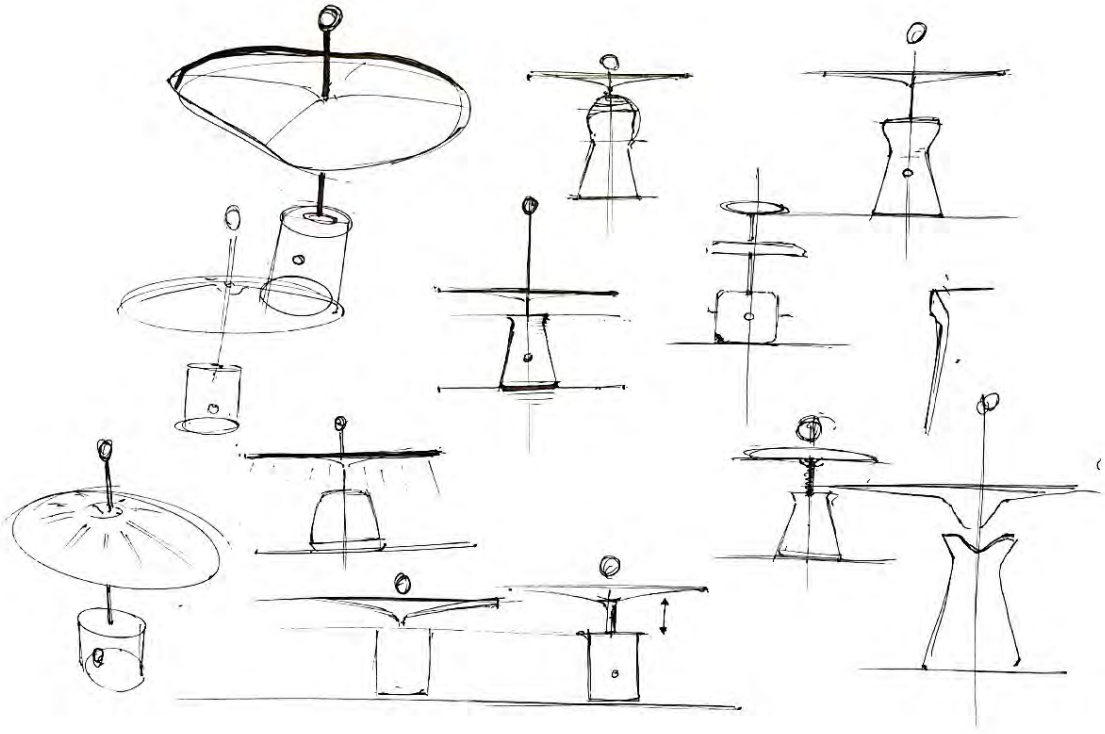
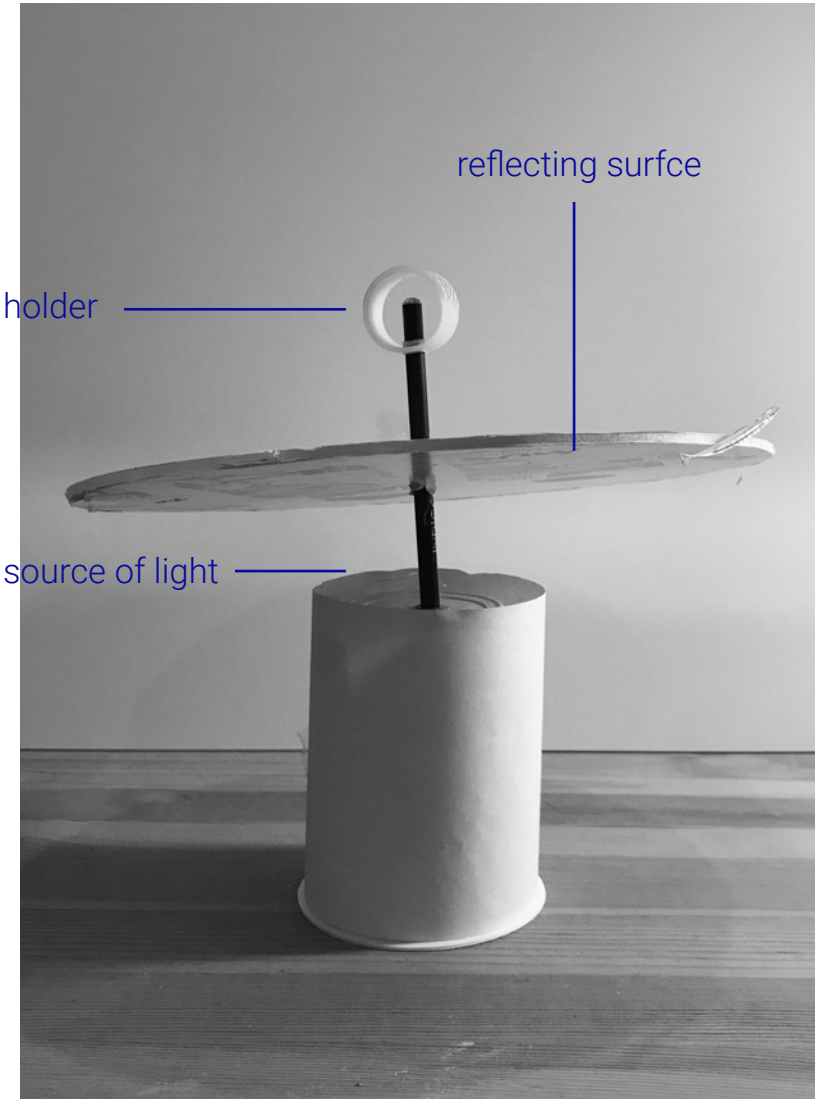
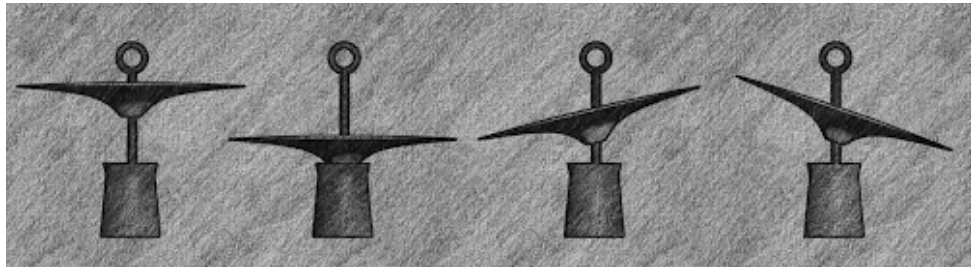


Figure 33: Sketches of Concept A



Thanks to its unique construction, the lampshade can move up and down and also tilt sideways. It makes the product ideally suited to each of the scenarios. The lampshade moved up to the top or suspended is ideal for Aperitivo. Illuminates a much larger area, table, and participants of such a celebration. The lampshade moved to the bottom makes the light more intimate and discreet, and people look more attractive. The ability to tilt makes the light directional, thanks to which it illuminates and makes reading more comfortable.



Aperitivo Romantic Dinner Reading a Book

Figure 34: Photos of the prototype of Concept A with the light source.

One of the big minuses of this concept could be overcomplicated lampshade adjusting mechanism. It would probably have to have a complicated system of joints and bearings, which are also demanding to maintain. Thus, an alternative version of the concept with a flexible, morphing shade was also presented. It was inspired by the product of the Australian company Muuto - Unfold Pendant Lamp. [27]

Figure 35: Sketch of the flexible version of Concept A

Figure 36: Muuto - Unfold Pendant Lamp

Concept B

In opposition to the concept A, the light sources were transferred to the upper part of the lamp and became an integral part of the lampshade. Thanks to this, an openwork frame could replace the massive bottom module, which gives the lamp a lighter impression. What's more, the frame is shaped to create a comfortable grip and indicates that the lamp is portable.

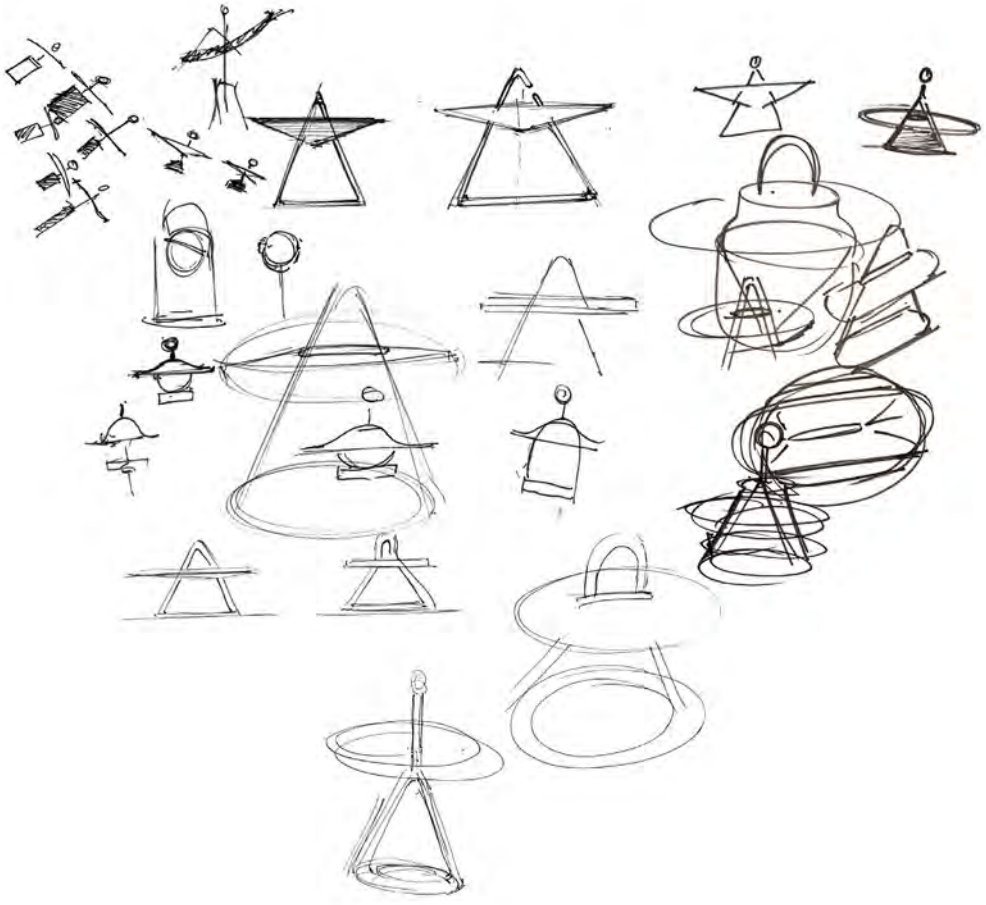


Figure 37: Sketches of Concpet B

Figure 38: Carboard prototype of Concept B

Similarly to concept A, the lampshade can change the height and angle of inclination, thanks to which it is adapted to three previously established scenarios. However, unlike the first idea, which required a set of complex mechanisms, this version was replaced by a simpler solution. Thanks to the cross-shaped cut with asymmetrical arms in the shade, depending on the arm on which the frame is based, the light sources could be located higher or lower, depending on the need *(Figure 39)*.

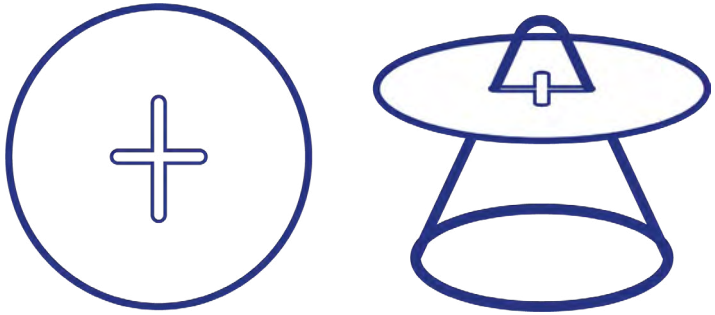
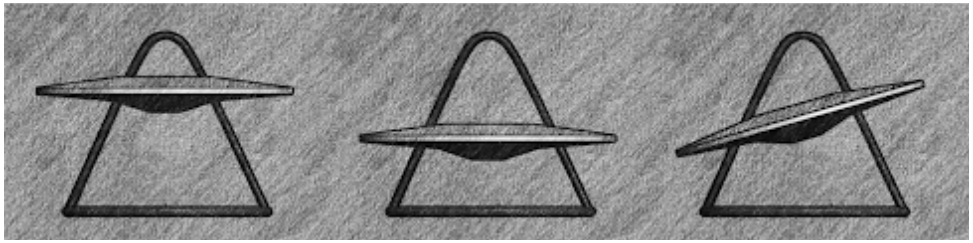


Figure 39: Cross shape cut idea



Aperitivo Romantic Dinner Reading a Book

Initially, the cardboard prototypes were made, which were then replaced by models made of bent tubes. It contributed to an improved impression of the weight and mass of the model and made interaction and experience more similar to intentions.

Figure 40: Illumination testing

Concept C

Inspiration for the third project came from the Brainwriting. One of the participants proposed to change the properties of light by turning the lamp from one side to the other. To support his idea, he presented the Trioli chair by Eero Aarnio. The ideas came to mind immediately. The concept's assumption is freedom of use, multifunctionality, and playfulness. Depending on the needs, the user can turn, rollover, stand upside down, etc. The correct lamp position is not determined because each position is correct.

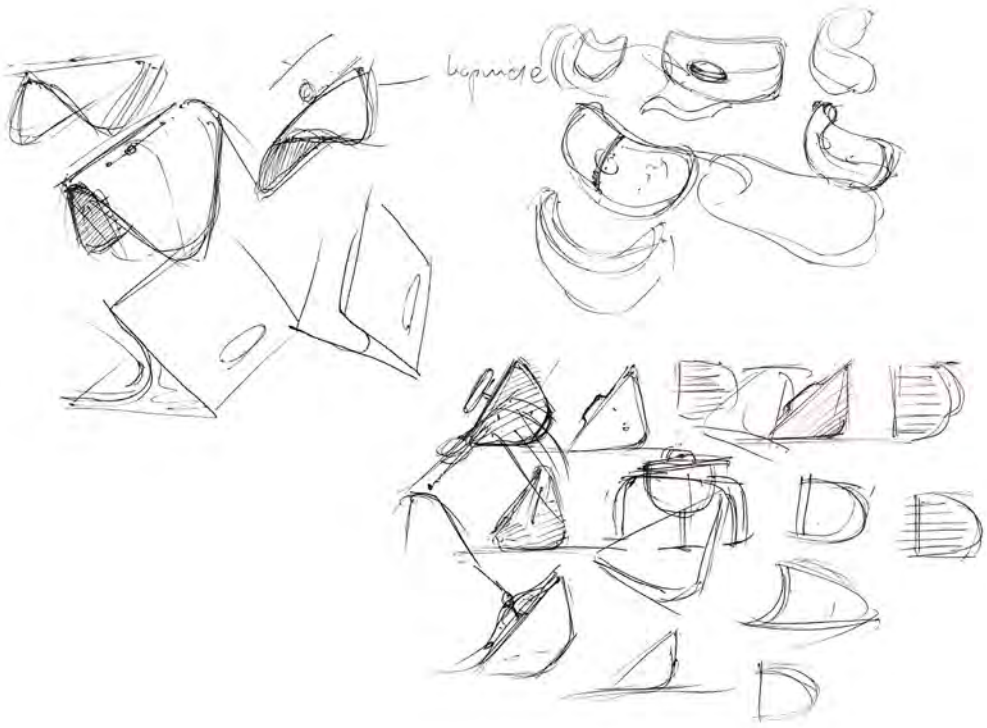
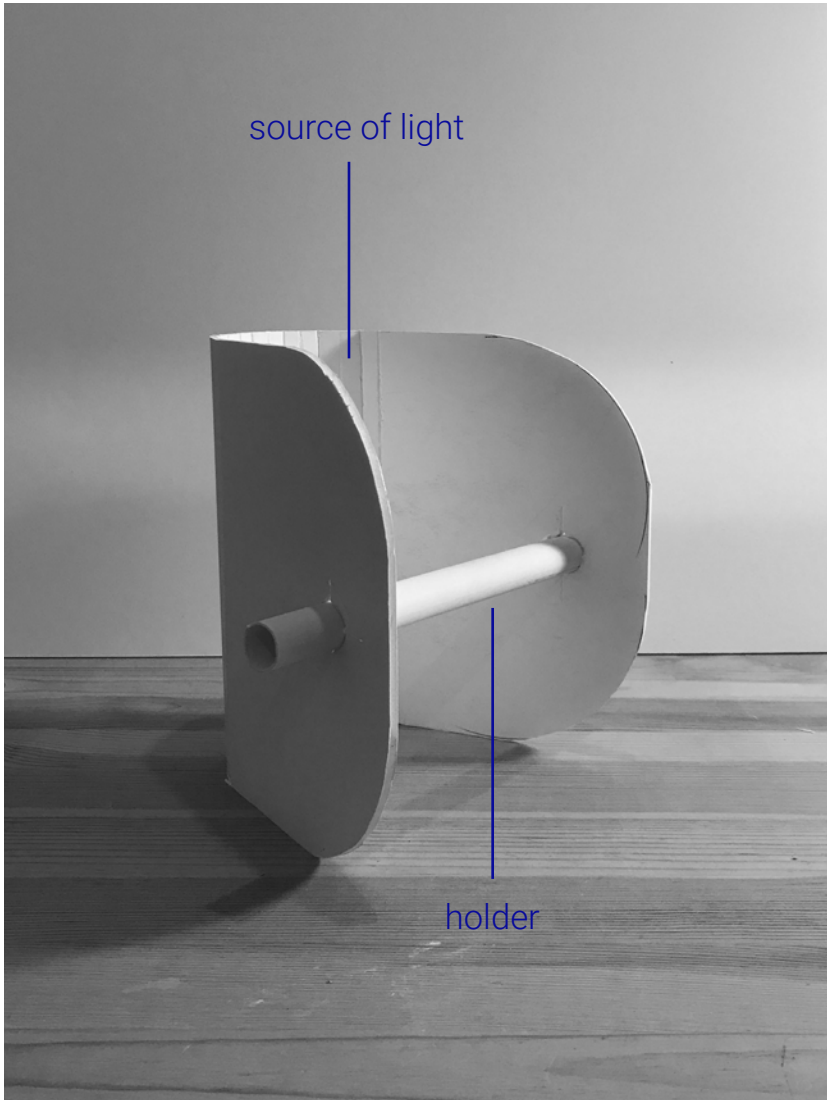


Figure 41: Sketches of Concept C



The lamp is characterized by its simplicity. It consists mainly of a piece of rounded, stiff material and a tube that serves as a handle. The light source is hidden inside the lamp.

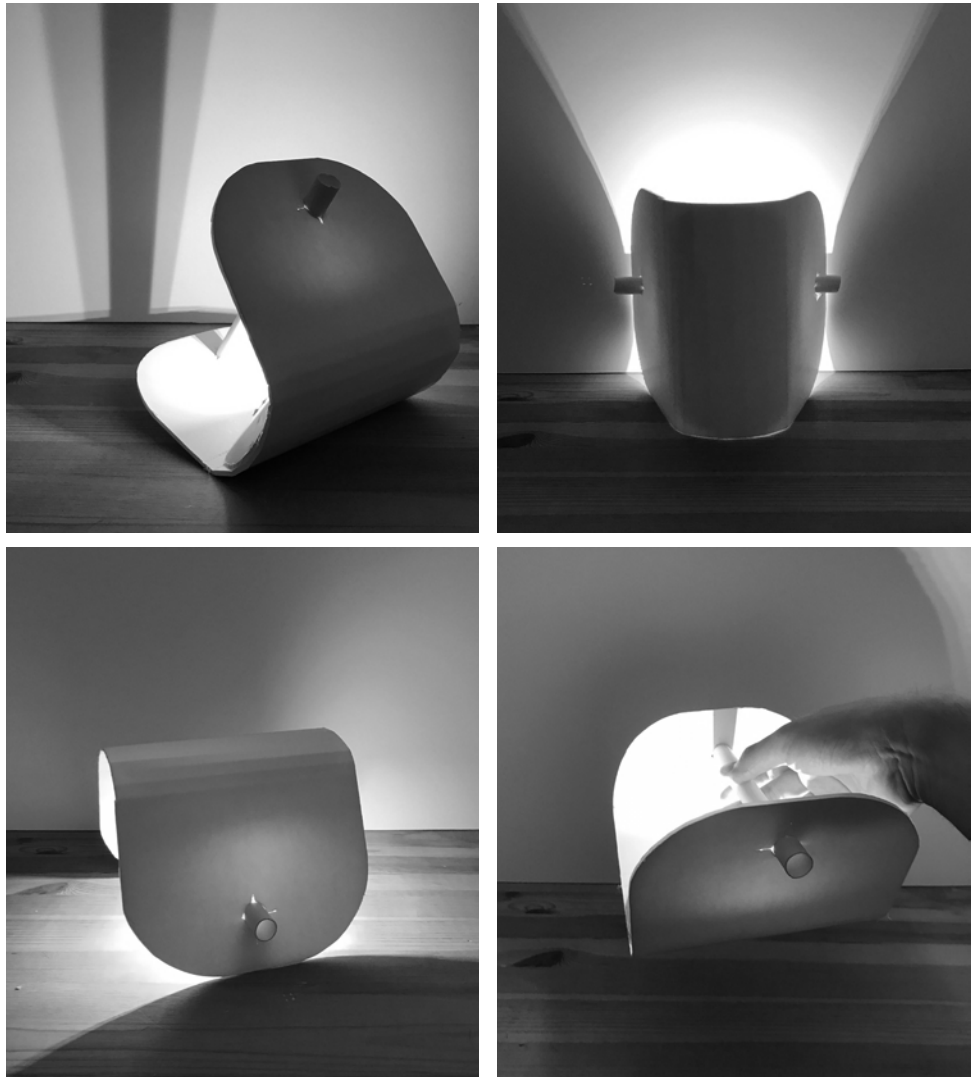
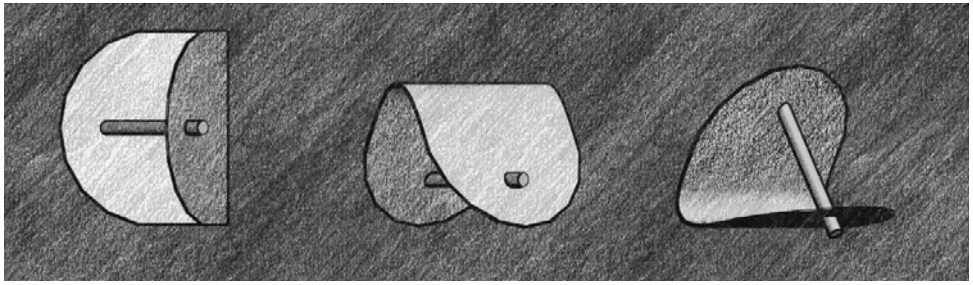


Figure 42: Carboard prototype of concept C



Aperitivo Romantic Dinner Reading a Book

As in the first two ideas, by choosing the suitable lamp position, the user can adjust the lighting to the appropriate scenario.

Concept D

Idea D is an attempt to deviate from the classic concept of the external lamp. It was to be used both at home and outside. Like the previous concept, this lamp is also characterized by a simple construction. At home, it was used most often on a base, which is also a charger. If there is a need to illuminate the outdoor, the user grasps by the handle and takes the light source itself without the base.

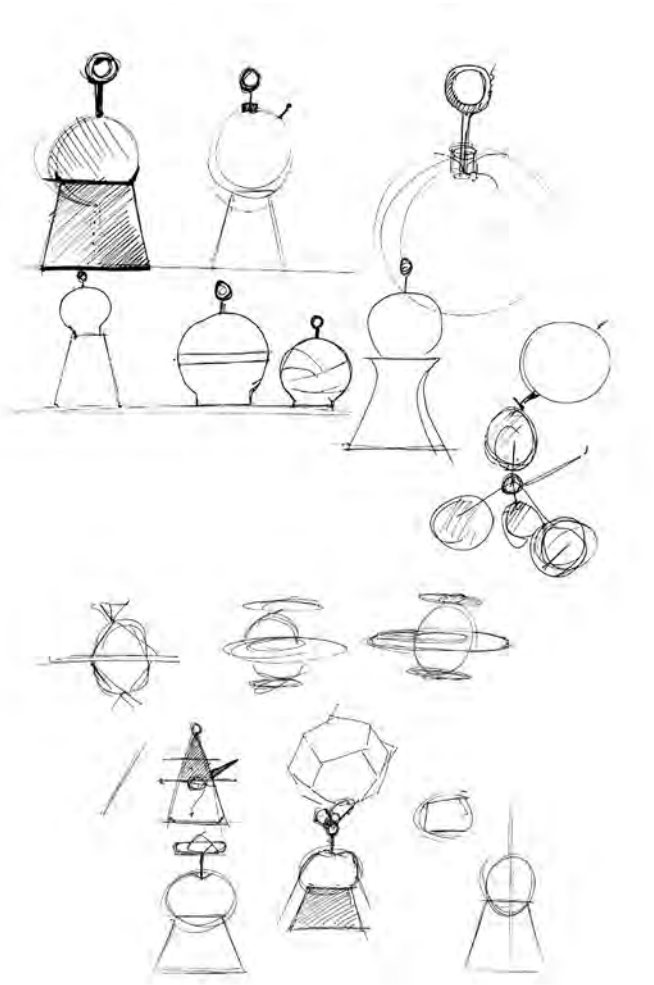
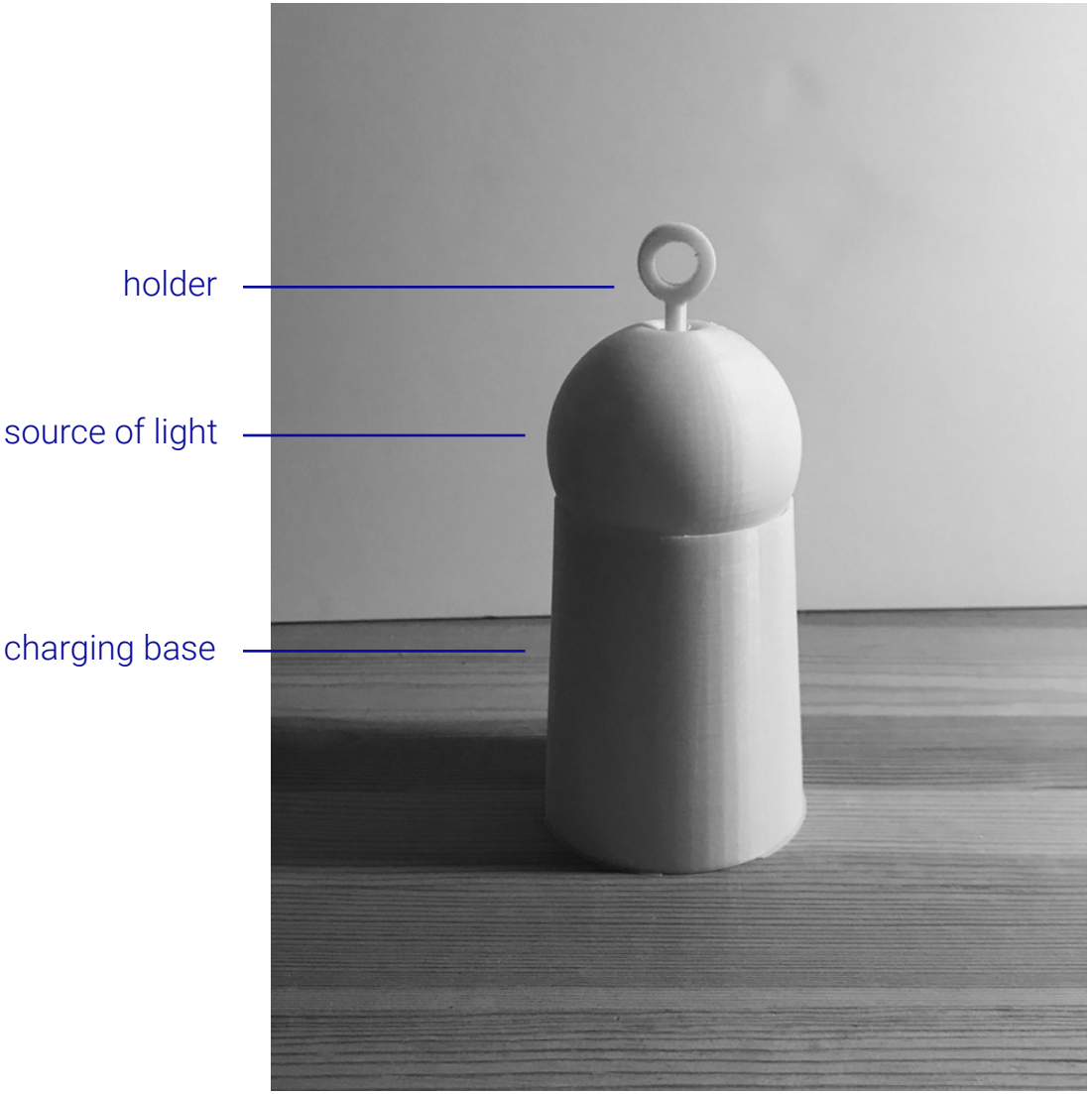


Figure 43: Sketches of Concept D



After the initial sketches, a 3D model was made and then the prototype was printed in the appropriate scale.

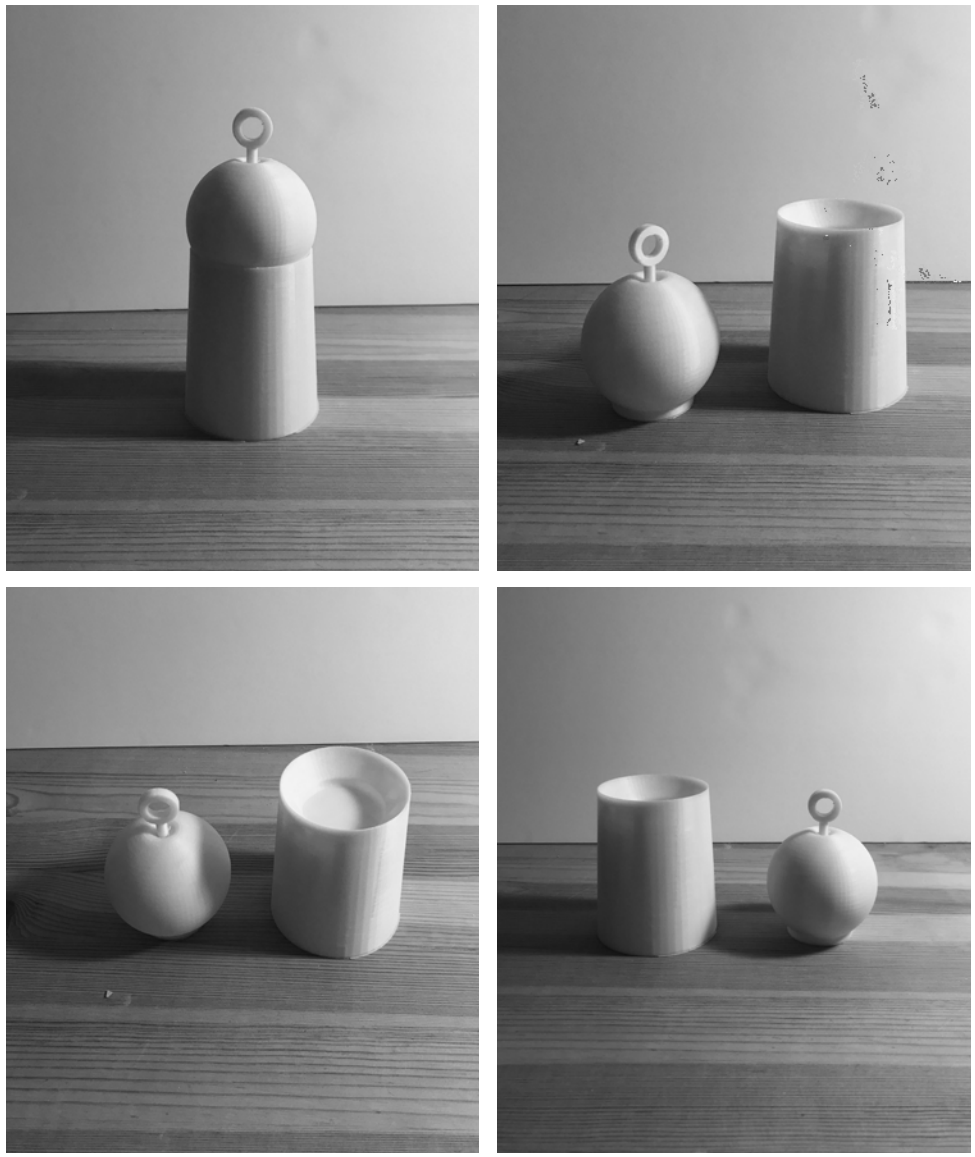


Figure 44: 3D printed model of concept D

Presentation

The concepts were presented to the supervisory team as well as a Representative of the Slamp. Particular interest in concept C was expressed. It was emphasized that the design would particularly suit the company's production capabilities. Moreover, the representative of Slamp highlighted the idea of using flexible materials (concept A) as potentially interesting for Slamp.

Ideation - stage 2

In the second stage of generating ideas, the focus was on two main goals: further development of the concept C, as well as seeking other applications of flexible materials in lighting design.

CONCEPT C.1

Continuation of work on the C concept began with subsequent moodboards and sketches. It was noticed that Concept C resembles a purse, which seems to be particularly interesting for Slamp because in many projects they refer to decorativeness and fashion. That is why a moodboard was made up of more and less known purses. The focus was not so much on the form as on the details and characteristic elements.

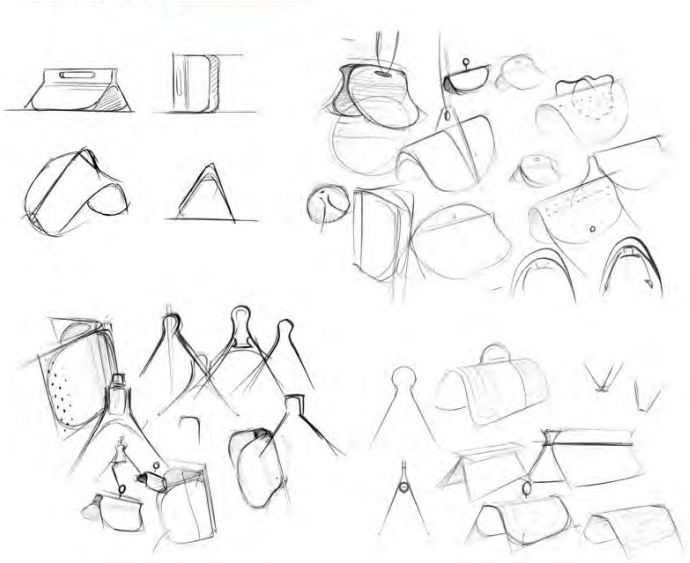


Figure 45: Sketches of Concept C.1

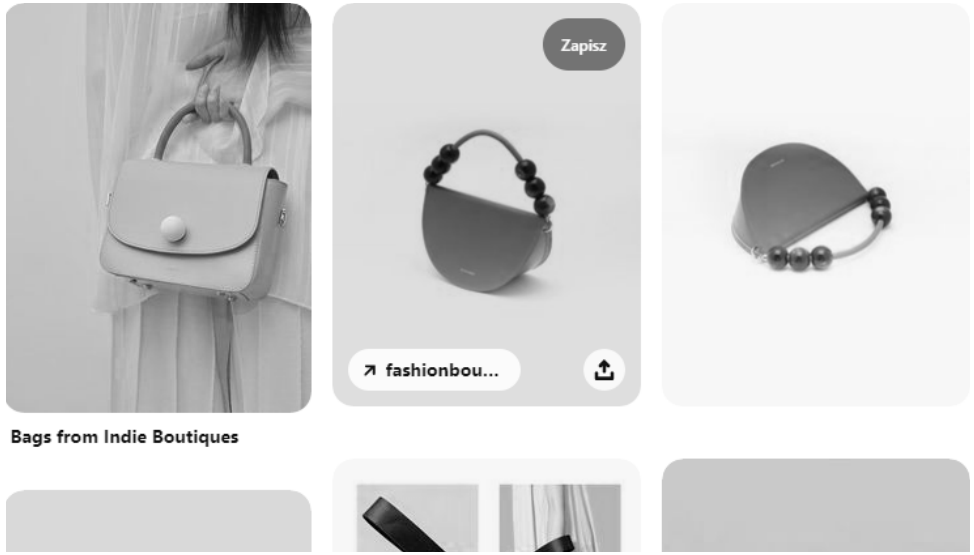


Figure 46: Part of Purses mood board

It was also decided to get rid of the tube that was supposed to be used as a handle. The reason for this decision was the non-functionality of this idea. In that case, by carrying the lamp by the handle, the light was directed upwards, and instead of lighting the floor, the user would be blinded.

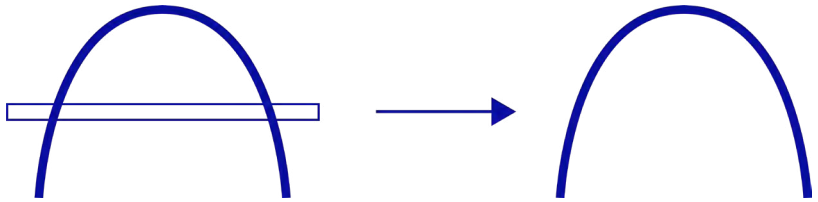


Figure 47: Getting rid of the inner tube

To search for the right proportions, roundings, and bending angle, apart from drawings and 3d models, cardboard prototypes were made. Experiments were also carried out with a handle placed on the back of the lamp, so that it could also be hung, e.g., over a table.

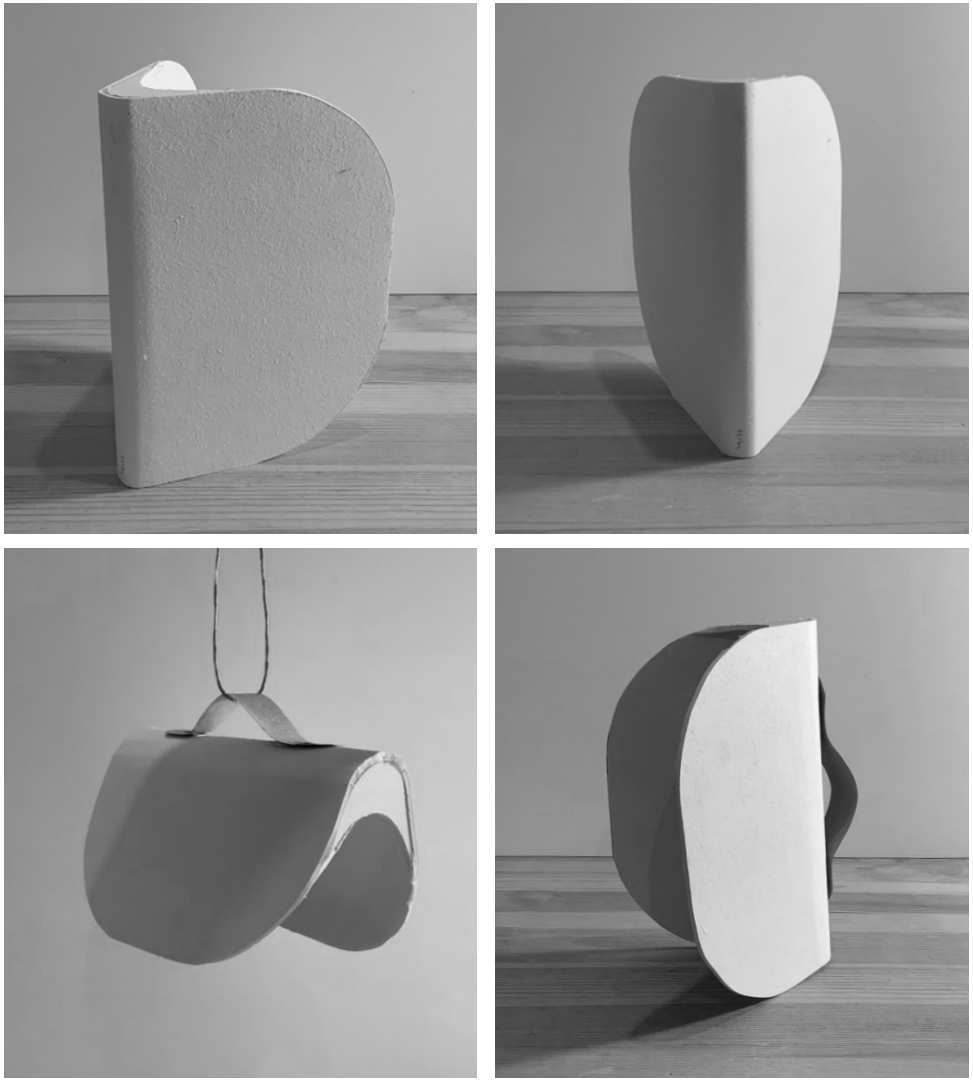


Figure 48: Carboard prototypes of the Concept C.1

After deciding to remove the tube that served as a handle, the lamp's ergonomics were also experimented. It was decided to create a slender narrowing on the top of the lamp, making it easier to grip and looking more alike woman's purse. To achieve better proportions, in this case, it was decided to use the „magic" proportions of Fibonacci, which often appear in nature, for instance, snails shells or human ear.

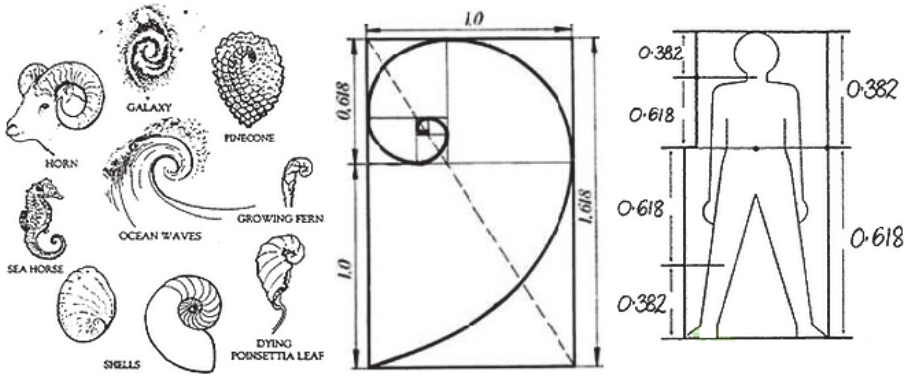


Figure 49: Fibonacci „magic" proportions

To obtain a better effect, reflecting the intended idea, it was decided to model the shape in a parametric software and print the shape on a 3D printer. PLA material was used, which can easily be sanded and easily painted. The shape was painted in a neutral, muted blue color.

Figure 50: 3D model of Concpet C.1

Scenarios for using the C concept were also rethought. It was recognized that the lamp fits most to creating an atmosphere on the terrace, balcony, or garden thanks to its particular form and type of given illumination. The C concept in the new version can be used in two different ways, vertically or horizontally. Horizontally, used, for example, during a romantic dinner, giving an intimate, delicate light illuminating the table. It also can be used vertically, accentuating the space around, plants or facades. For the best effect, it is recommended to use several lamps at the same time.

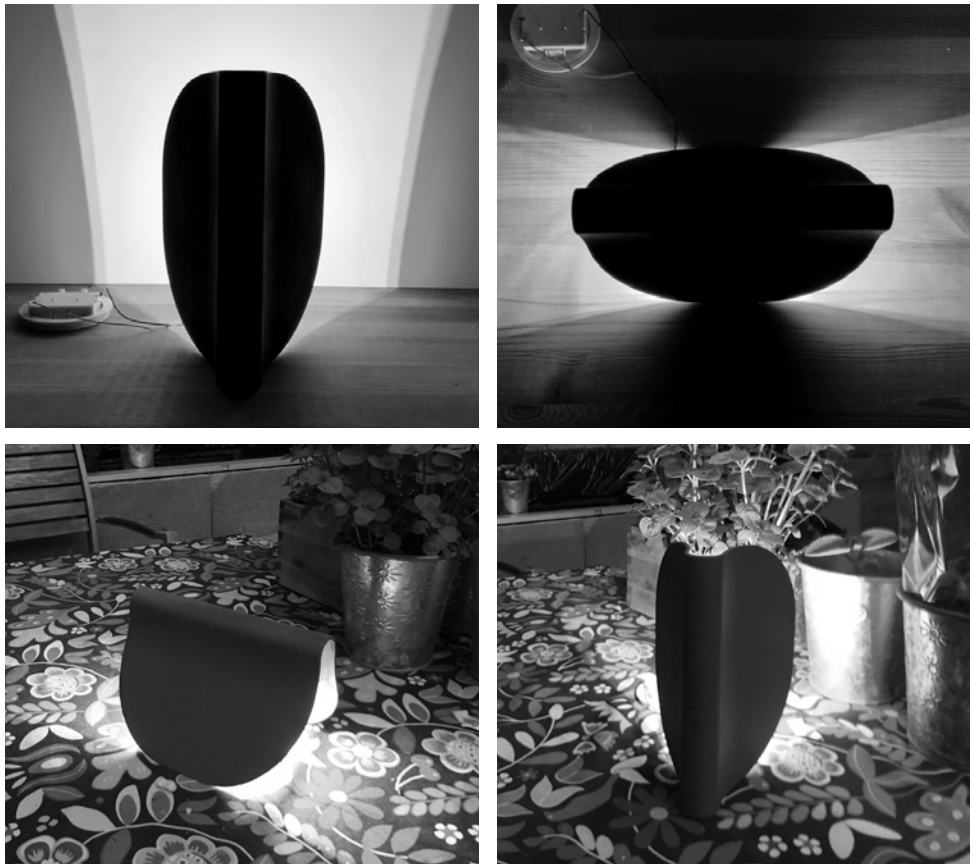


Figure 51: Lighting testing

Furthermore, there were also attempts to design handles on the back of the lamp, which were also printed on a 3D printer. However, it was recognized that they disturb the appealing simplicity of the lamp.

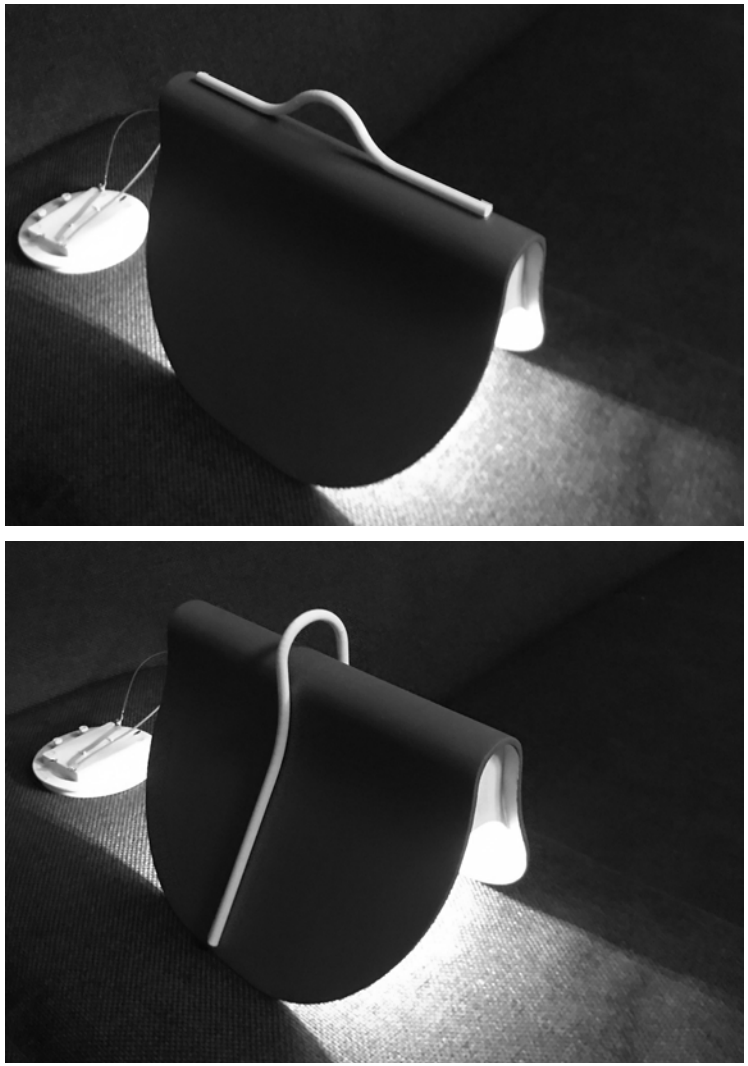


Figure 52: Handles

To fit in the product more to Slamp's portfolio, there were attempts to give patterns that could be printed using the capabilities of the company and digital printing on the surface.

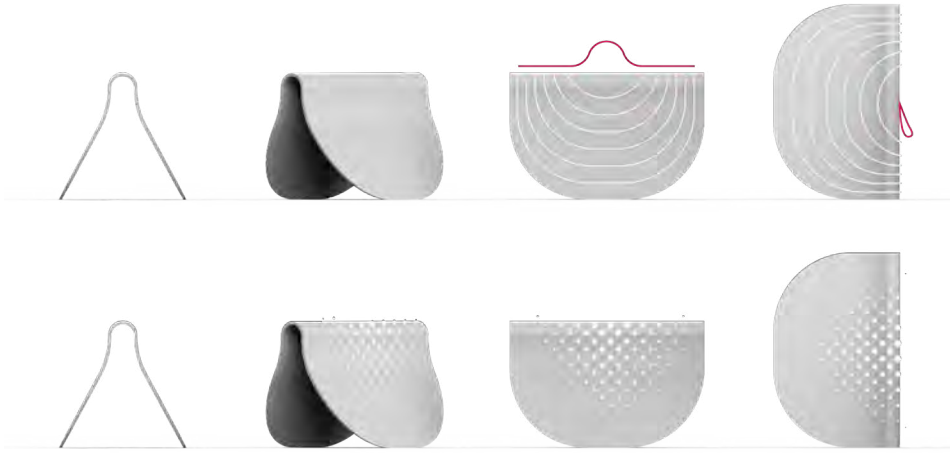


Figure 53: Patterns

Concept E

After the first presentation, Slamp representatives clearly expressed interest in the possibilities and potential of flexible materials such as rubber and silicone. Following their guidelines, ideas for the use of these materials in lighting design began to be generated.

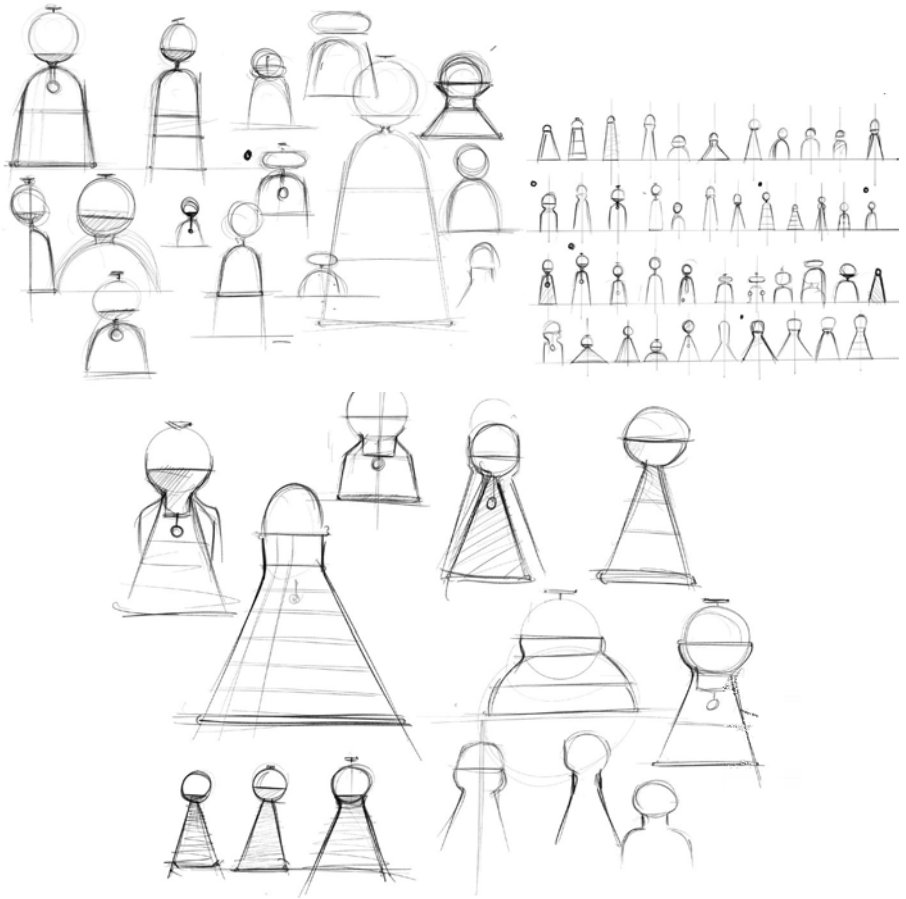
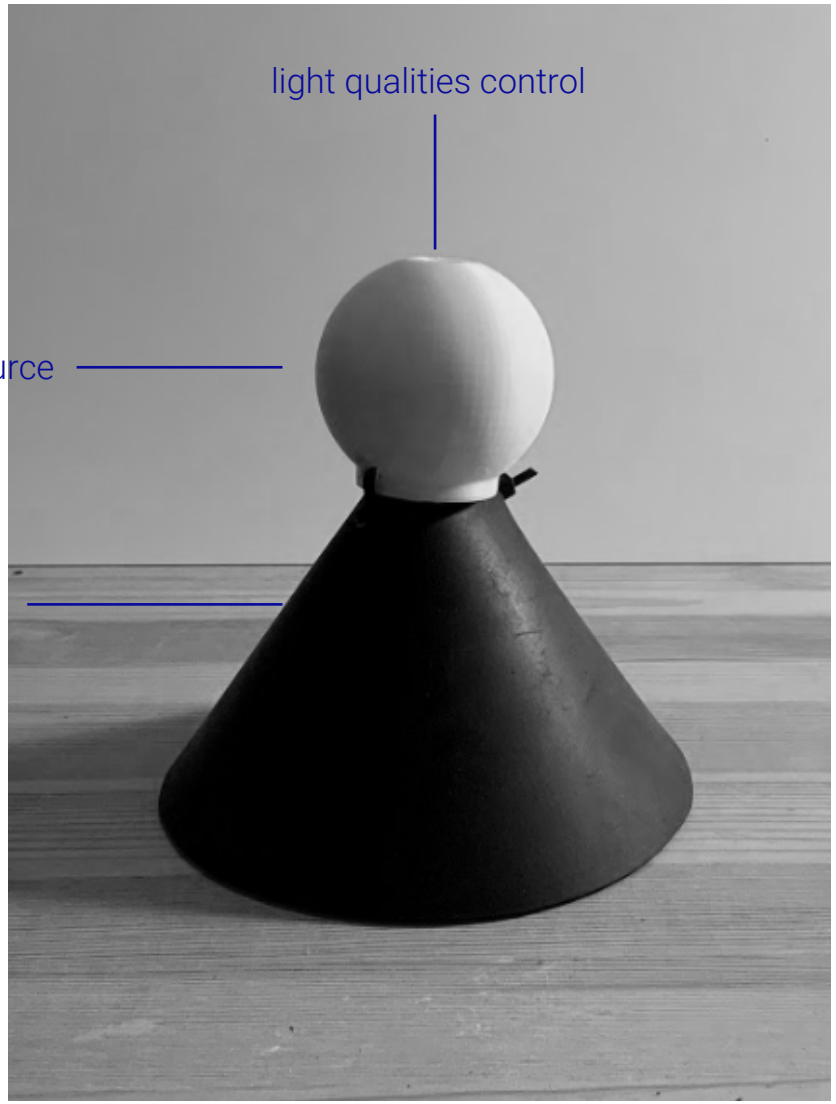


Figure 54: Sketches of Concept E



Surprisingly quickly, the idea of a double-sided lamp appeared *(Figure 55)*. The idea is to use a flexible lamp base, which can be the basis for a table lamp or, after flipping it around, becomes a lampshade for the ceiling lamp. In addition to the flexible base, the lamp also consists of a diffused light source, light quality control on the top, and a circle that appears after the lamp is flipped around, on which it can be hung.

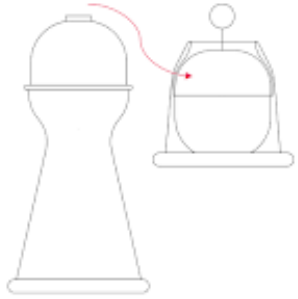


Figure 55: Lamp transformation

Figure 56: Lamp transformation prototype

To imitate the asses the working principle of the concept, the rapid prototype was created. It consists of a 3D printed ball, imitating a light source, suspension ring, and a flexible base, which for the needs of the model was made of a sheet of rubber.

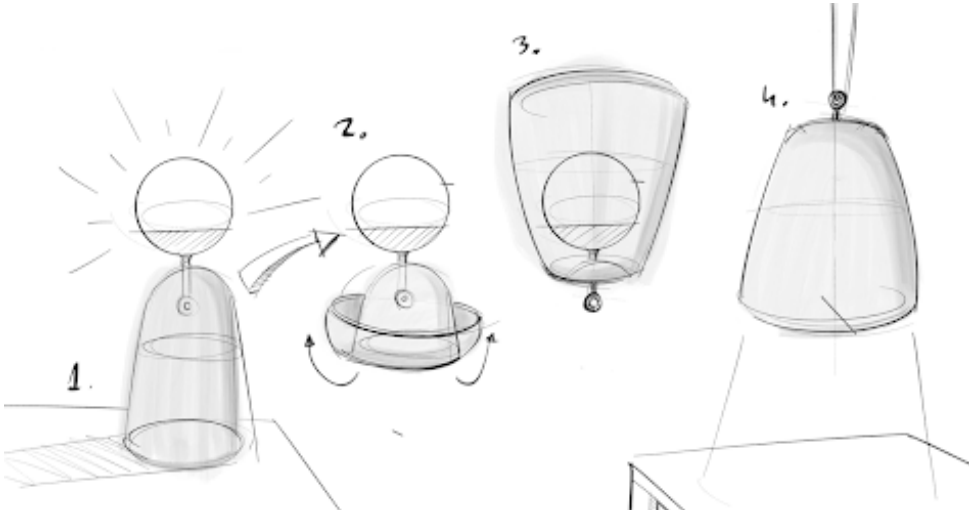


Figure 57: Transformation process

Soon, a 3d model was made in a parametric modeling software, which was afterwards printed. This activity was aimed at finding a suitable, aesthetic form of the product and physical evaluation of the design.

Presentation

The supervisory team and Slamp representatives enthusiastically evaluated the progress of work on the concept C. Particularly important for Slamp was the inspiration with fashion and women's purses. Moreover, regarding the „Silicone" concept, the supervisory team advised further development with particular consideration to form, proportion, and appearance.

Ideation - stage 3

The third stage of ideation was primarily devoted to the concept with a flexible base. The unique characteristics of the concept required more attention, which made work extremely time-consuming. Regarding Concept C, the work mainly focuses on the interaction and consideration of light's qualities that the lamp should have.

Concept E.1

As before, work on the form began with dozens of small sketches. Sketches, which in the subjective assessment had the potential, were marked with a dot and then drawn at a larger scale and developed later.

A difficulty to this concept was that in the initial position, the lamp located on the table for obvious reasons could not take up too much space on the table, while in the flipped around form, the larger volume of the lampshade means more space that is illuminated. It became clear that it will be necessary to find a compromise between two modes of lamp occurrence.

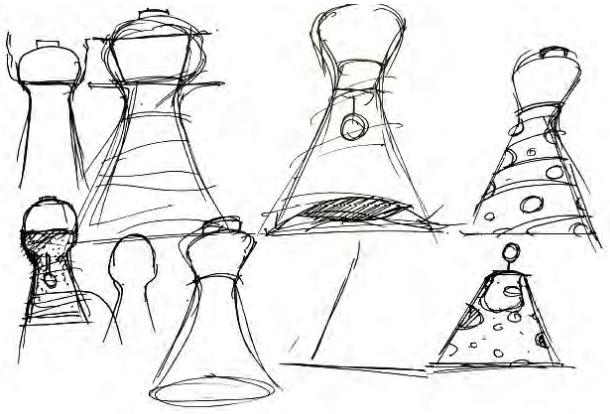
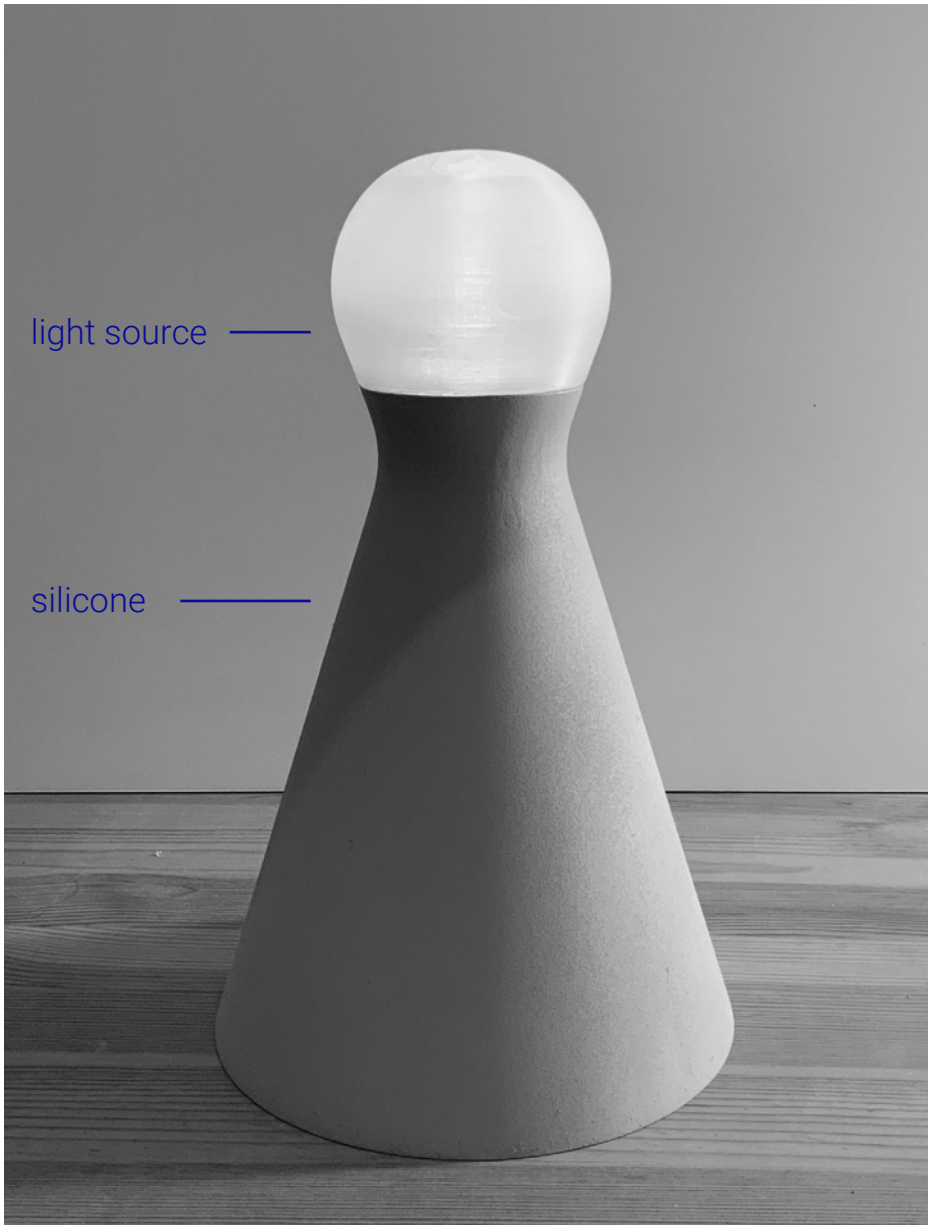


Figure 58: Sketches of Concept E.1



These circumstances meant that the best solution would be to design a relatively tall and narrow lamp. Another important aspect is the material bending position while flipping around. Depending on the bending place, in the ceiling lamp mode, the light shade can be adjusted. The higher the bend is, the more curtained is the light source *(Figure 59)*.

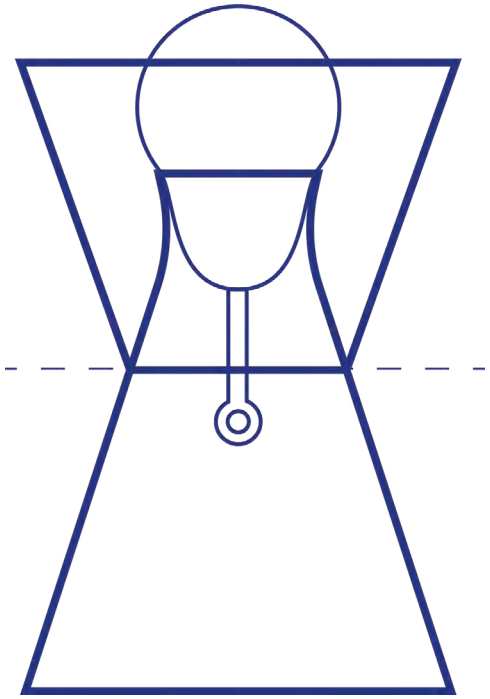


Figure 59: Lamp transformation

A tall, slim, and organic form of the lamp was introduced (*Figure 60*). Because of the form, it was recognized that the best way to prototype the lamp would be 3D printing. Before that, the CAD model in Solidworks was made. Since only stiff materials such as PLA were available, it was decided to print rigid lamp models in two modes - table lamp and ceiling lamp.

To imitate the asses the working principle of the concept, the rapid prototype was created. It consists of a 3D printed ball, imitating a light source, suspension ring, and a flexible base, which for the needs of the model was made of a sheet of rubber.

Figure 60: 3D printed appearance model of the Concept E

The appearance model was not enough. To test the working principle and interaction with the lamp, it was necessary to use silicone, rubber, or material similar in properties to these two. It was decided to purchase Fiberlogy FiberFlex 30D - flexible filament for 3D printers, produced in Poland. It has similar properties as rubber, but most importantly, to obtain the desired form, it is not necessary to produce expensive molds. It is perfect for the early stages of a project when you are still looking for the right form.

Due to its characteristics and flexibility, FiberFlex is not easy to print. Moreover, it is mandatory to reduce the printing speed significantly. Therefore, to save time, it was necessary to cut the height of the model, which translated into the number of attempts in one week.

By trial and error method, a series of flexible bases were made. The first attempt failed because the wall thickness of the base turned out to be too thick. What's more, the lamp was printed with infill set to 10% so that the material was too stiff and impossible to flip around.

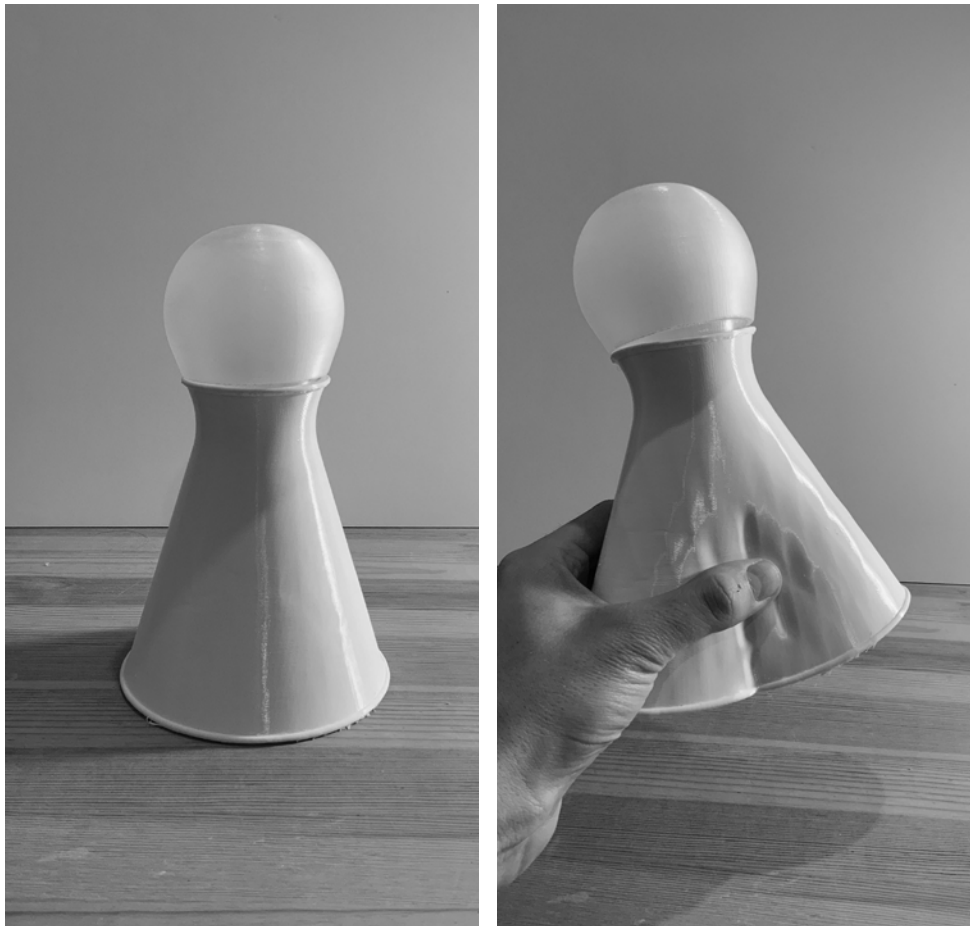


Figure 61: First attempt

In the second attempt, the wall was thinned to a thickness of 1.5 mm and infill set on 100%, however during the flipping around the test; the material was shaping in a very unsightly, unpredictable way.

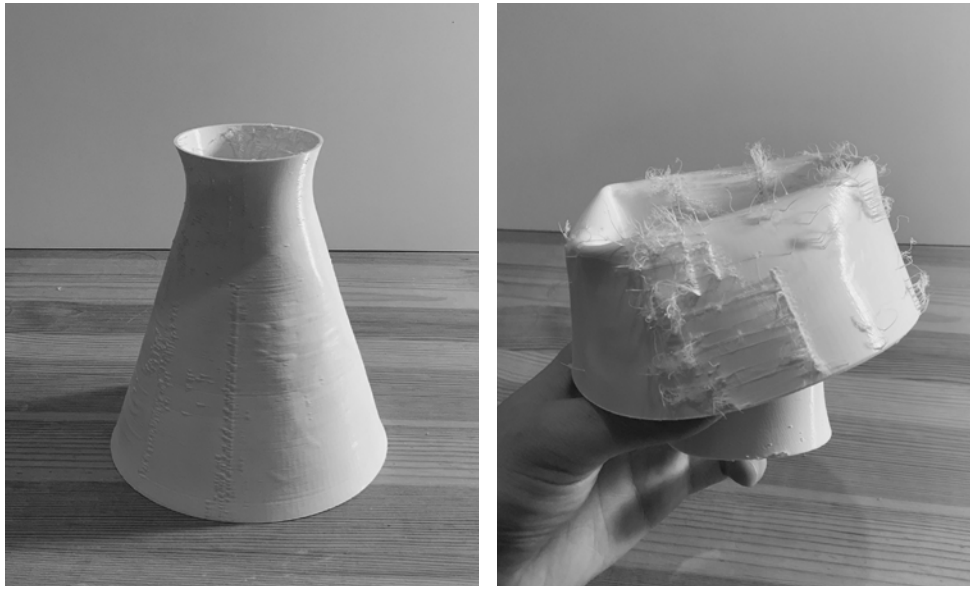


Figure 62: Second attempt

In the third attempt, in order to facilitate flipping around, bending lines were designed. Thanks to that action, the material behaves in a more tamed way, only in preset locations.

Figure 63: Third attempt

In addition to its functionality, this action gave the lamp an element of playfulness. The user can play, bend, flip around, set the object according to his whims and needs. In the ceiling lamp mode, the light source may be more or less covered, same as in table lamp mode - the light source may be higher or lower.

Figure 64: Lamp transformation

Finally, a full-size lamp's functional model, which same as the appearance model, was also printed.

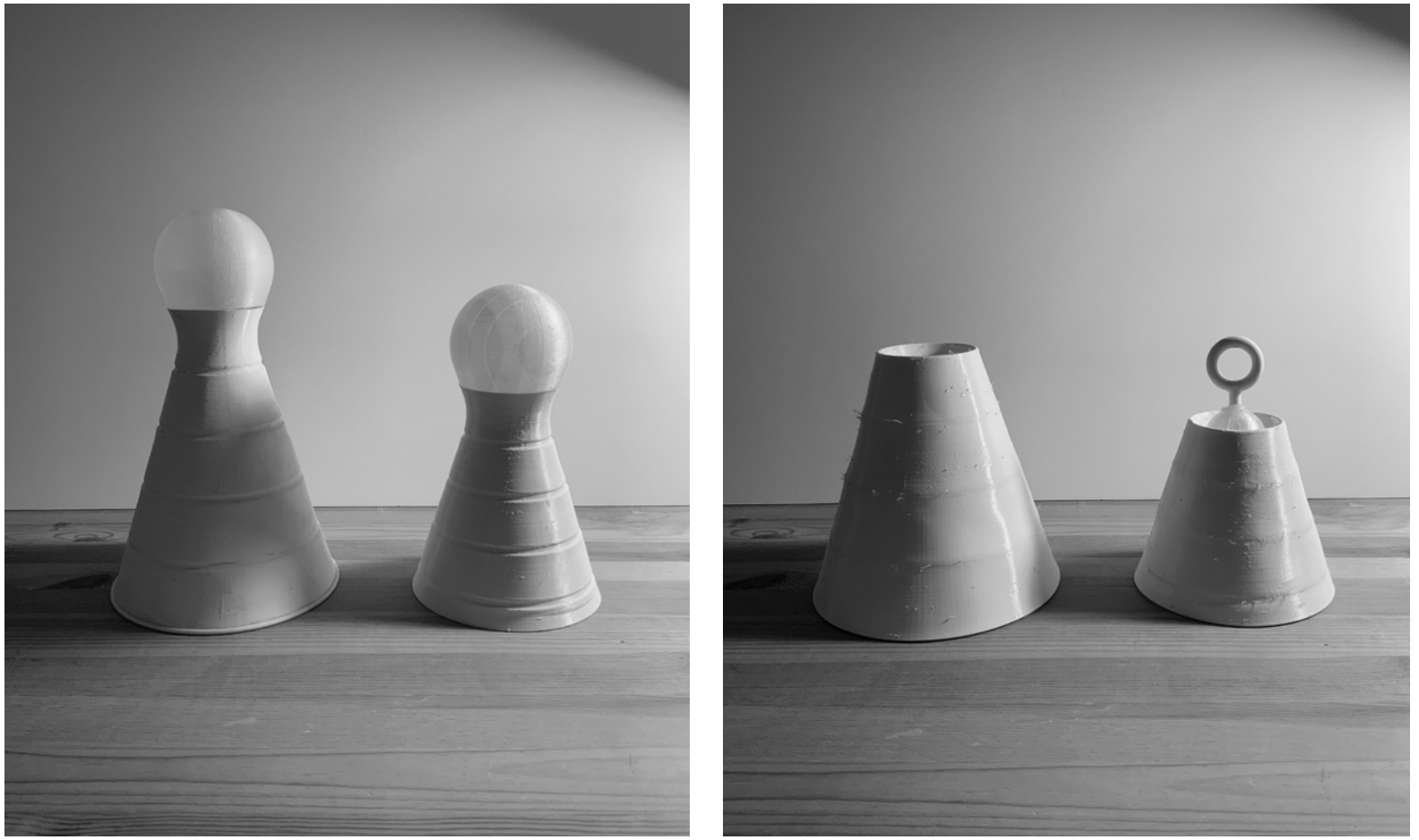


Figure 65: Full size functional model

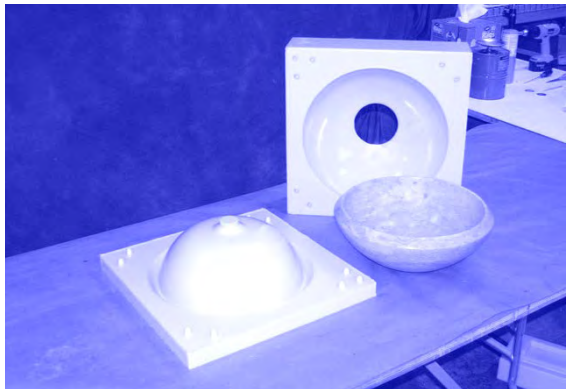
To obtain more information about the properties of materials, production possibilities, and possible methods of manufacturing of the flexible element of the concept E, the Kauposil company was visited. They specialize in the distribution of flexible materials such as a wide selection of silicones and rubbers, as well as in the production of molds and castings.

Figure 66: Manufacturing method of Kauposil

The project was presented to an expert who, after thoroughly familiarizing himself with the operation principle and the conditions to which the lamp will be exposed, suggested VytaFlex 60 - Urethane Rubber by Smooth-on. Urethane rubbers have properties very similar to silicones, but what is important, they are characterized by a slightly higher stiffness, which is crucial in the case of the project. The mold could also be made of the same material.

The company was also asked to evaluate the cost of the mold and casting of the lamp. The price of mold production, together with the material, is 128,60 €. The mold can be used hundreds of times. In turn, the cast's price is 32,74 €, including the cost of material 10,13 €.

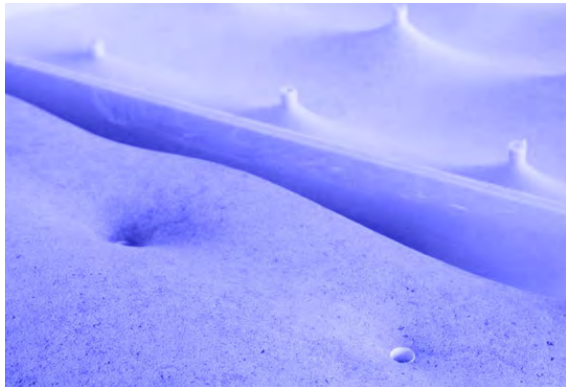
MOLD



material + mold production

126,60 €

CAST



VytaFlex 60 urethane rubber - casting

32,74 € (10,13 € per unit)

Concept C.1 - Interaction

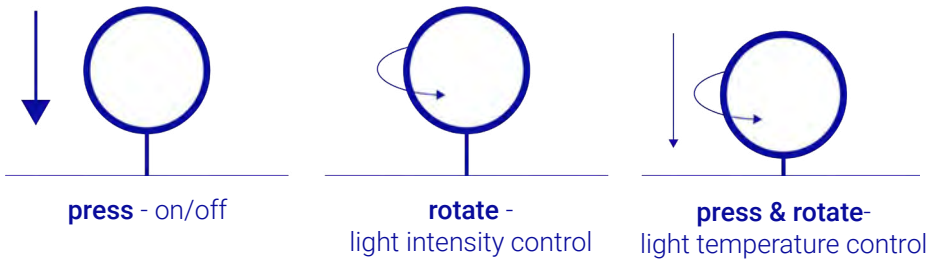
The experience of using the lamp is just as relevant as the appearance. A product with a poorly designed UI can lead to frustration. However, before designing the UI of the lamp, the question should be asked - what properties of light we want to control?

Not only the appearance of the lamp but also the qualities of the light must match the portfolio, and the values presented by Slamp. Slamp avoids colored light. The leading quality of light, which is different depending on the lamp, is color temperature. Additionally, a portable lamp can be used in various places, situations, and scenarios. In situations requiring more intensity of light like Aperitivo and intimate ones such as a romantic dinner for two. The light is used to emphasize or change the atmosphere. Researchers proved that even gentle change in color temperature and intensity has a significant impact on the perceived atmosphere. What is more, the respondents of the interview, which was carried out in the early stages of the project, as one of the most annoying problems, indicated finding the bulbs with right color temperature, matching to those previously used in the garden.

For these reasons, it was considered that the optimal solution for this type of lamp would be to give the function to control the intensity of light and color temperature.

Figure 67: Concept C.1

An ideation and sketching session was carried out. It was considered that a functional and user-friendly solution could be to use a rotary encoder. This solution makes it possible to turn the light on and off as well as allow a user to control the intensity and color temperature of the light.



It was deemed that the best place to position the encoder would be the top of the lamp. Thanks to this, the light's properties can be easily changed in the horizontal position, as well as in the vertical position, regardless of the side on which the lamp will be placed.

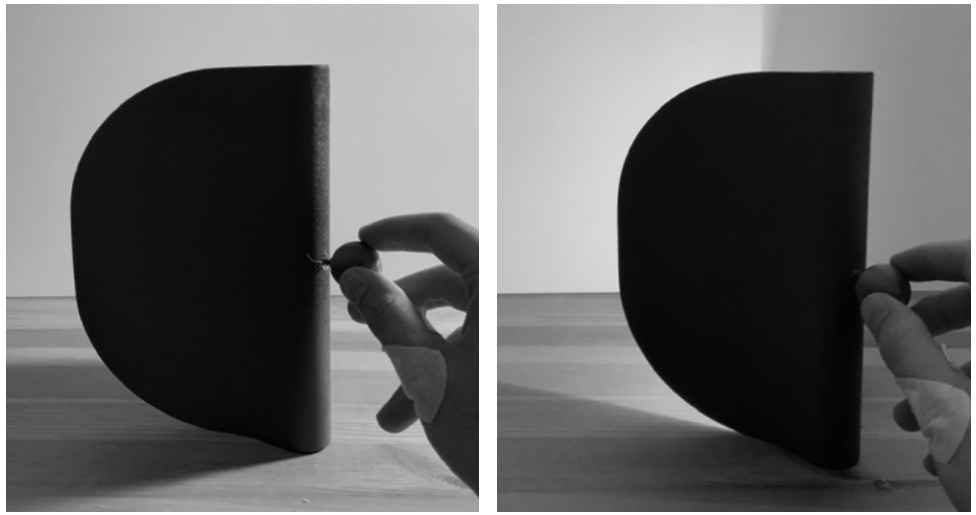


Figure 68: Interaction testing

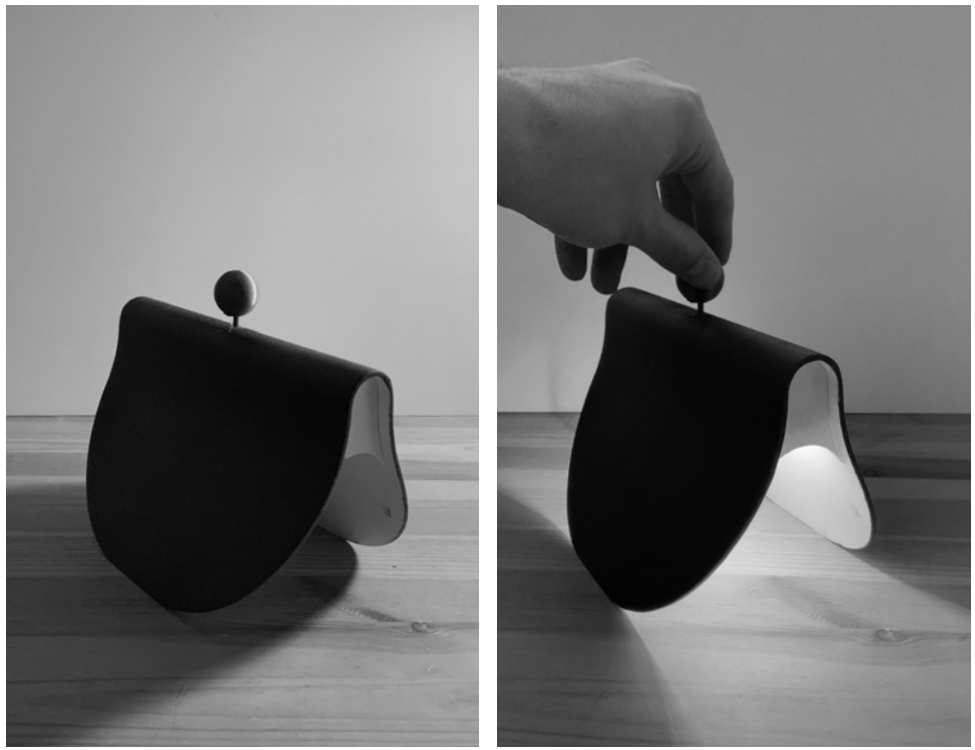


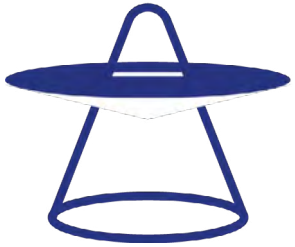
Figure 69: Interaction testing

Decision making

After the concept development process, the moment has come to decide which of the concepts best suits the Slamp portfolio, has the greatest potential, and will be developed into a detailed version in the next steps of the design process.

Three concepts were taken for final evaluation. There were selected the ones that emerged the most interest from the supervisory team and, above all, from Slamp's representatives, including the artistic director.

Concepts chosen for final evaluation:



Concept B

Concept C

Concept E

To help Slamp make decisions, and facilitate discussion it was decided to use proven methods such as Harris Profile and Weighted Objectives. [26]

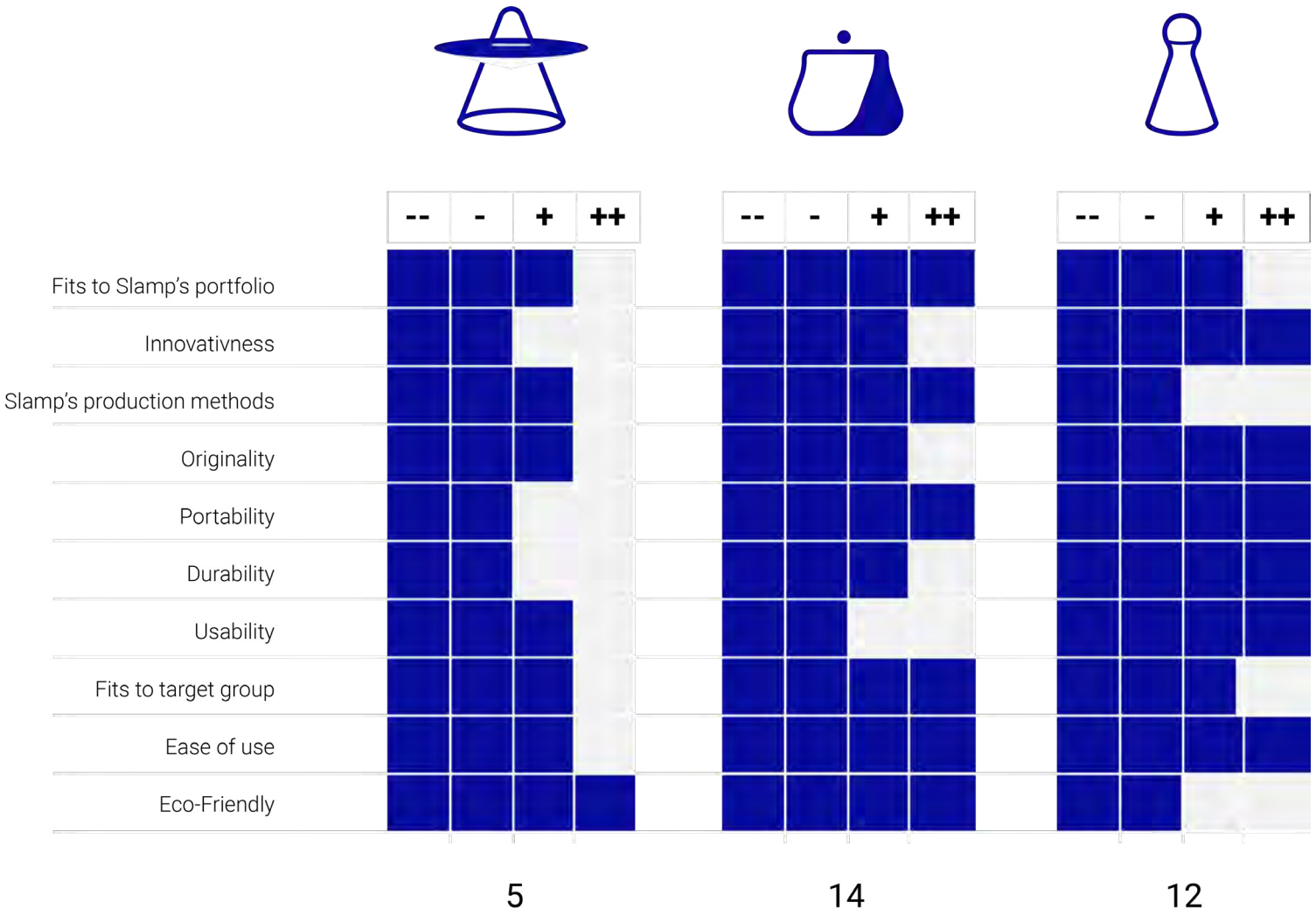
To use the methods, requirements and values relevant for Slamp were listed and ranked according to their importance for the project:

most important

- Fits to Slamp's portfolio
- Innovativeness
- Originality
- Portability
- Durability
- Usability
- Ease of use
- Ease of implementation
- Fits to target group
- Sustainability

Afterwards, the four point matrix, coded -2 ,-1, 1, 2, for each requirement was created. Three concepts were evaluated on a 4-point scale, for each of the requirements. Finally, the results were presented next to each other in order to easily assess which of them achieved the best result and to ease the discussion

As a result, concepts C and E obtained by far the best results, overwhelming concept B.



Due to identical results of the C and E concepts, it was decided to use the Weighted Objectives Method [26], in which criteria used to evaluate the design differ in their importance. The weight of the category is assigned depending on its importance for the final evaluation. Each of the concepts was rated on a scale of 1-10 in each category, and the overall result was multiplied by the set weight.

This time again, you can see a clear difference between the leading Concepts C and E and Concept B. However, the difference between the Concepts that obtained the highest number of points is insignificant, only 20 points.

	Weight	Score	Total	Score	Total	Score	Total
Fits to Slamp's portfolio	20	7	140	9	180	8	160
Innovativeness	15	7	105	8	120	9	135
Originality	10	7	70	8	80	9	90
Portability	10	7	70	8	80	9	90
Durability	10	7	70	8	80	8	80
Usability	10	8	80	7	70	9	90
Ease of use	10	8	80	8	80	8	80
Ease of implementation	5	7	35	9	45	8	40
Fits to target group	5	8	40	9	45	8	40
Sustainability	5	8	40	8	40	7	35
Score: 1-10		**Total Score**	**730**	**Total Score**	**820**	**Total Score**	**840**

At the end of the presentation, a list of all Slamp values was also presented, and an open question was asked - which concept best fits the company's vision?

SLAMP
THE LEADING LIGHT

VISIONARY
ADAPTABLE
SENSUAL
MYSTERIOUS
INNOVATIVE
ACCESSIBLE
RELIABLE
ASPIRATIONAL
ORIGINAL
RESOURCEFUL
EXPERIMENTAL
SUGGESTIVE
HANDMADE

Final Choice

After a lively discussion with Slamp representatives, the C concept was best suited to Slamp's vision and will be further developed in the next steps. Furthermore, the concept's reference to the fashion world, elegance, design, and business potential were emphasized. Besides, representatives of Slamp highlighted the ease of implementation and intelligent use of Slamp's current production capabilities.

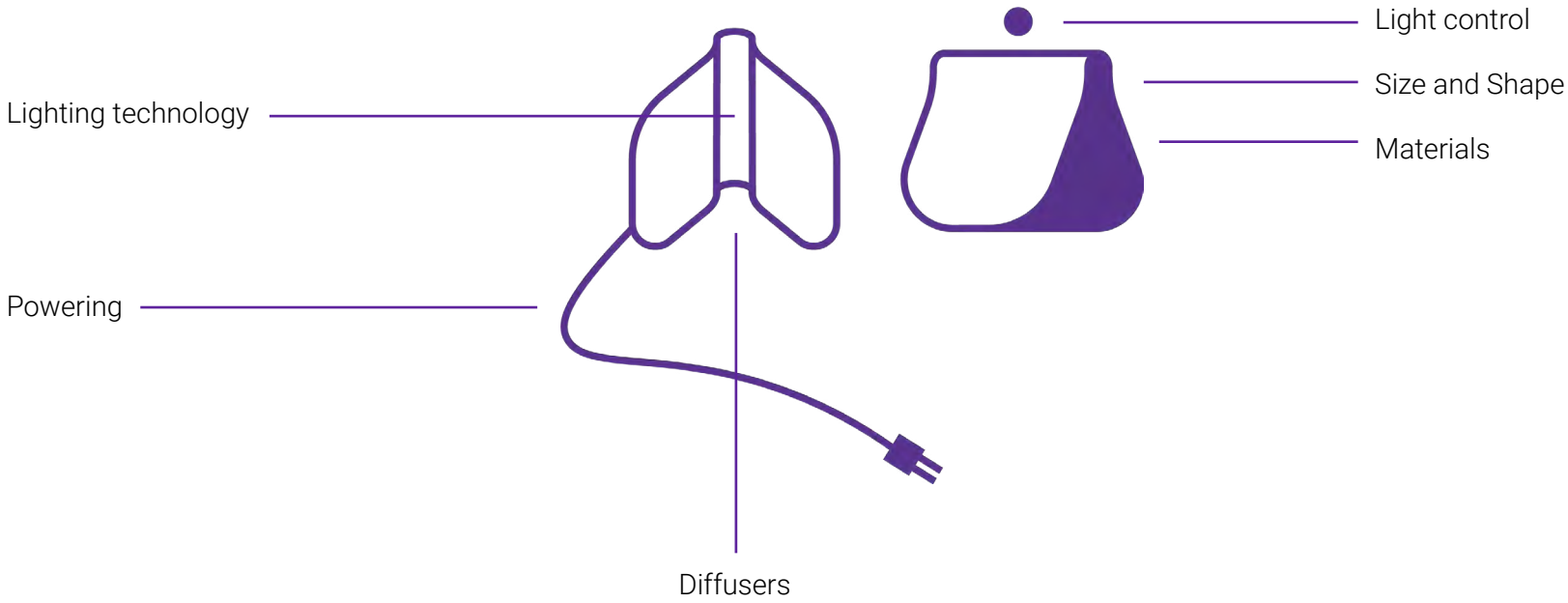
Concept C

Detailing

After the concept development phase, concept generation, and finally choosing the best one, it came to the Concept Detailing Phase. This phase is not just about embodiment design and detailing elements such as powering, lighting technology or the final selection of materials. It is also a broader view on the chosen concept, thinking of some earlier ideas and generation of new solutions, perhaps contradictory to previous ones.

Direction Details

To organize the detailing phase, facilitate project work, and better project overview, the selected concept was divided into subcategories. The most critical elements that require reflection or development have been identified. It is also sort of a list of decisions that must be made before the final stage and the final prototype.



List of Requirements

Based on previously acquired knowledge, market analysis, and consultations with representatives of Slamp, the List of Requirements was formulated. Requirements have been grouped and divided into categories.

Performance

- LED technology
- Battery life: **minimum 5h of maximum light intensity** ~5000 mAh
- Recharging to max - less than 4H
- Color temperature between 2700 and 3000K

Ergonomics

- design should indicate that the product is portable and mobile
- product must be easy and comfortable to carry

Interaction

- On/off
- Seamless Light intensity and color temperature control
- Seamless charging experience

Materials

- easy to clean
- Lightweight
- Not easily damaged
- scratch proof

Environment

- lighting should be safe for flora and fauna
- production of blue light should be limited
- minimal energy consumption for maximum performance
- Color temperature up to 3000K

Standards, Rules and Regulations

- Minimum IP44
- IK>5

Production Facilities

- Possibly, maximum use of Slamp's production techniques
- Other production methods are possible

Aesthetics

- Product fits to SLAMP's values and products portfolio

Size and Shape

The first step was to zoom out and a broader view on a chosen concept. However, efforts were made to maintain the product's character and functionality. Traditionally, it began with sketching sessions and rapid prototyping.

The creative session's first result was the idea for a lamp consisting of textiles stretched on a rigid frame. The idea was a direct reference to women's purses. The textile stretched on the frame, in addition to aesthetic values, also has a functionality of a light diffuser. In order to evaluate the first impression, the prototype made of bent aluminum tubes was made.

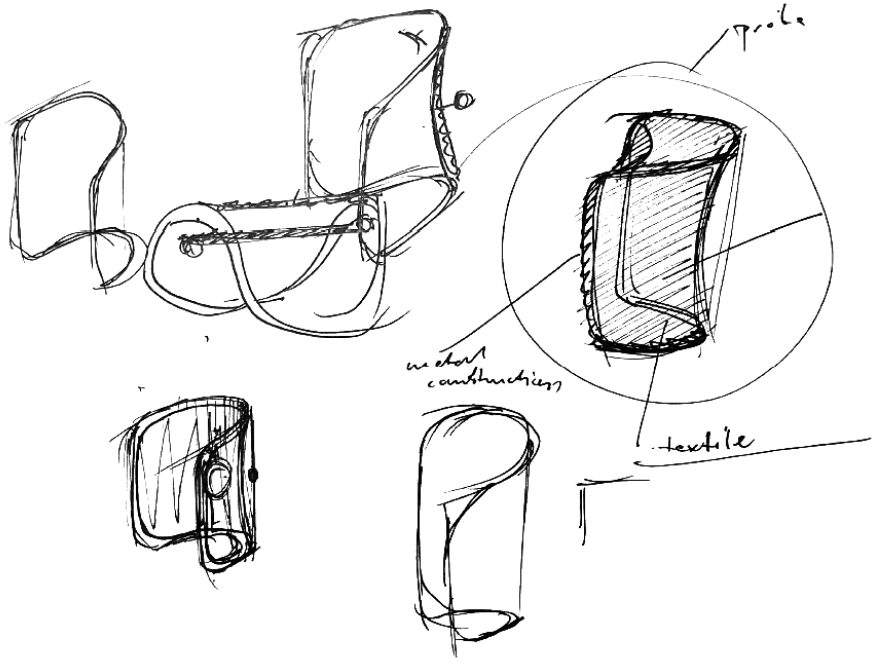


Figure 70: Sketches of new shape directions

Figure 71: The prototype of new direction

By following the idea of stretched fabric, the idea of a hybrid emerged, combining the previous approach with the idea of fabric on the frame. The outer lamp housing is made of a relatively rigid material such as steel, aluminum, or plexiglass. The center of the lamp is made of thermoformable plastic imitating tensioned textile and diffusing light.

To imitate the appearance, as well as the working principle of the diffuser, renders were made.

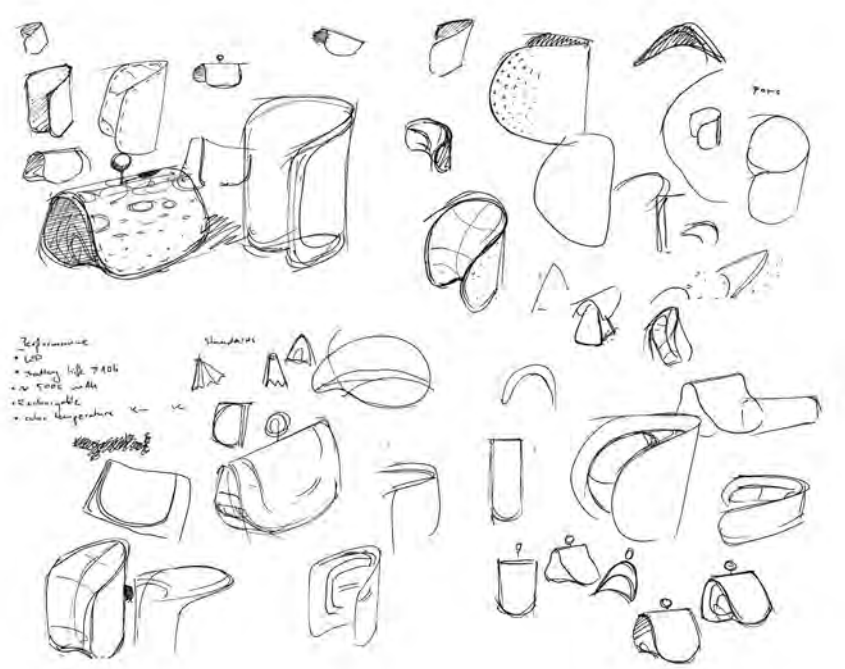


Figure 72: The hybrid idea sketches

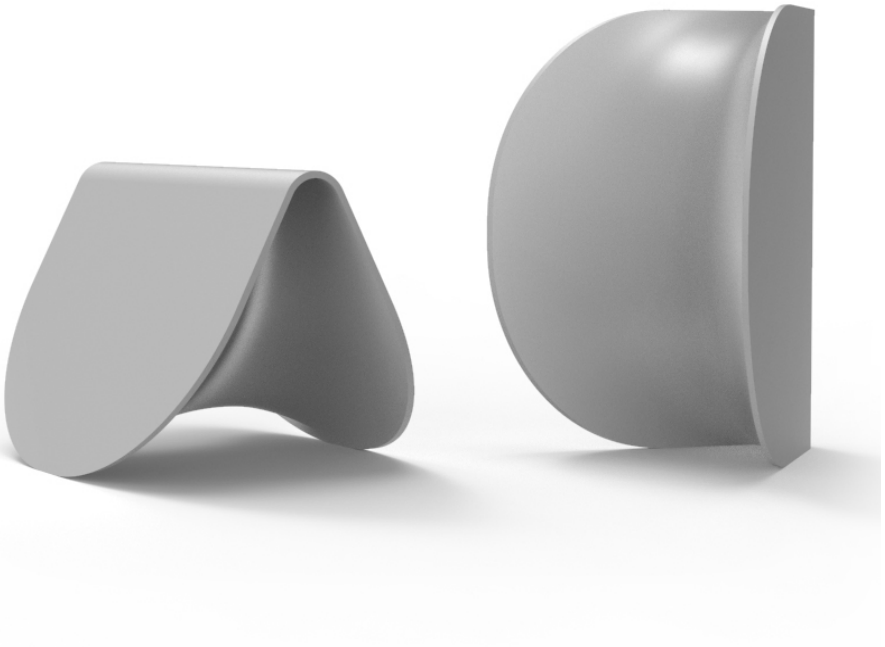


Figure 73: The hybrid idea render

Simplified Shape

Compared to concept C, the new form is more straightforward. As we can see, after unfolding the material, thanks to the elongated shape, the product can stand in a vertical position. The side section resembles the curved letter A. The material's bending radius has also been increased, thanks to which the product has a modern, organic form. It was essential to keep a reference to the fashion world and purses, despite the change in shape.

A preliminary model was made in the parametric program, which was then rendered in the Keyshot program to assess the aesthetic values.

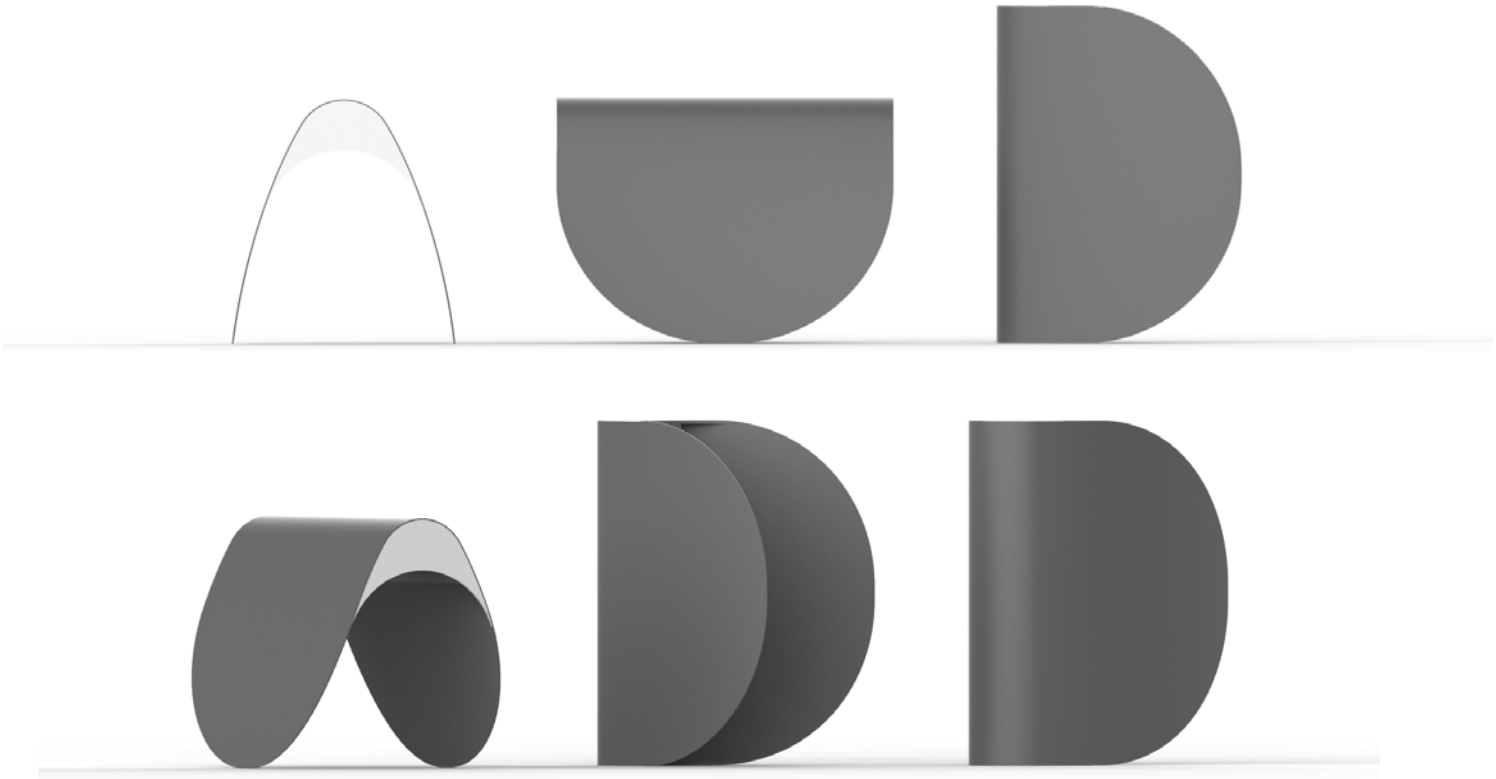


Figure 74: Render of simplified shape direction

Shortly afterward, after a preliminary aesthetic assessment of the model, a 3D print of the product's outer shell was made. Moreover, to assess the illuminating potential, an alternative light source was used inside the model.

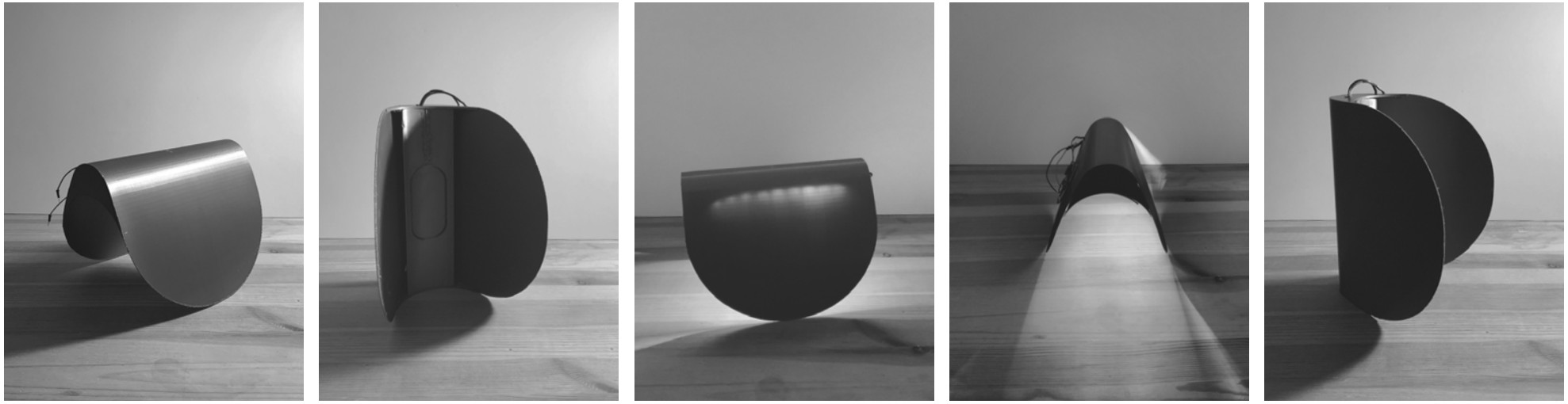


Figure 75: 3D printed simplified model

While designing, production ergonomics, which has a crucial impact on sustainability, were also considered. The unfolded lamp has dimensions of 331 mm x 195 mm. It means that up to 15 lamps can be cut from a standard metal or plastic sheet. Material loss is minimal.

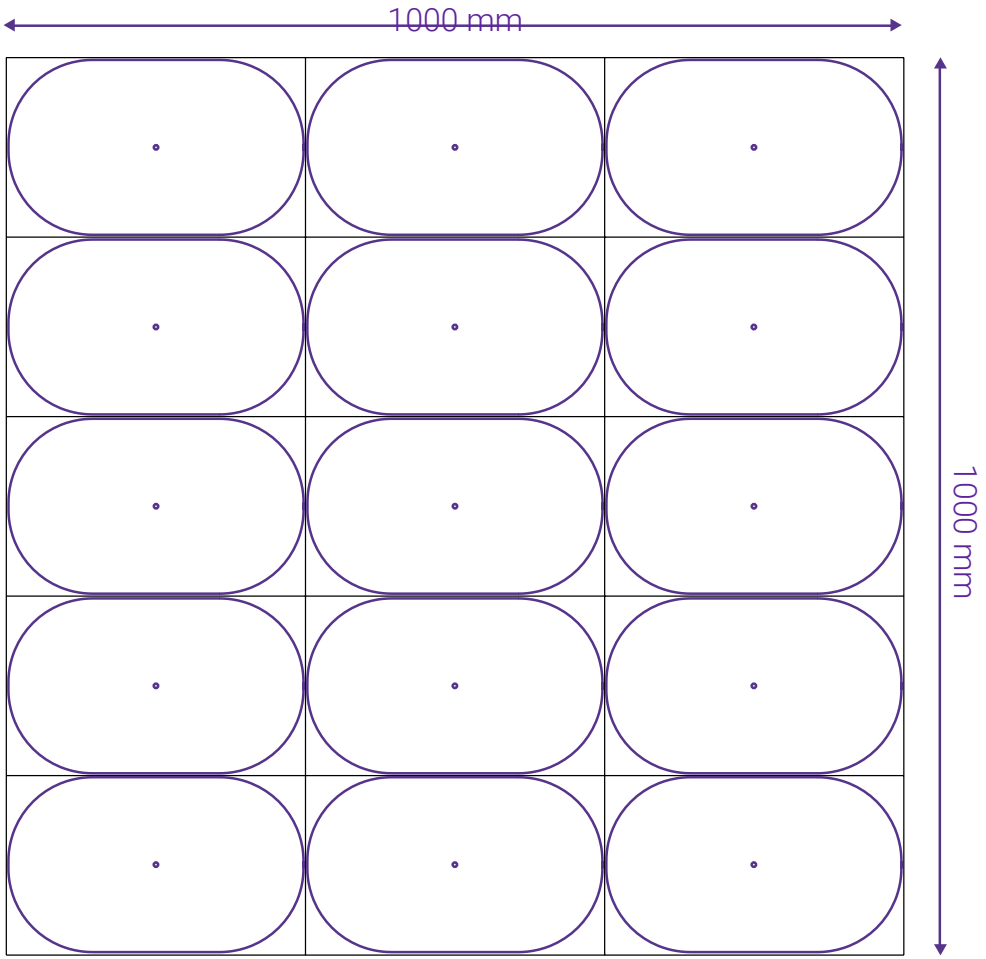


Figure 76: Sheet of material prepared for laser or cold cutting

Material Selection

In order to find the right material, a desk research was carried out. The goal was to gather as many different types of products that stood out through the interesting use of innovative materials or the innovative use of traditional materials.

Initially, it was broad research, including textiles, but later it turned into a search for rigid, stiff, and bendable materials (*Figure 77*). Obviously, atmospheric conditions to which the material may be exposed were also considered.

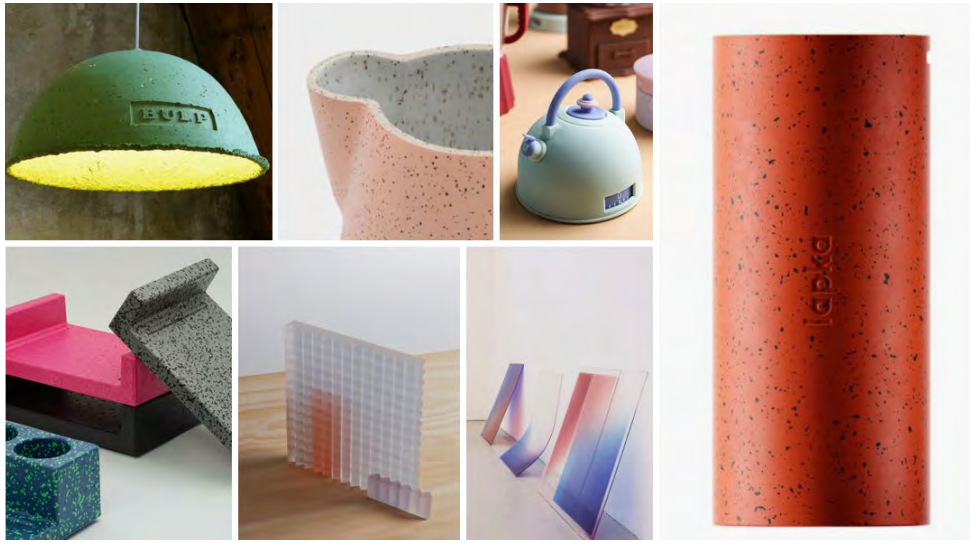


Figure 77: Part of the materials moodboard

Steel

The first material highlighted is steel. It is a fairly obvious choice. However, very functional, reliable, and sustainable. Well protected, it has great strength and good weather resistance. Importantly, the metal sheet can be painted in an unlimited number of colors. Furthermore, it is possible to print on the surface of the sheet and also engraving, which can be an important advantage. The sheet metal is also easy to process and cut, which can be done by the CNC method, which is already being used by Slamp.

The use of this material by Slamp would require additional investment, e.g., in shaping presses or use of an external manufacturer.

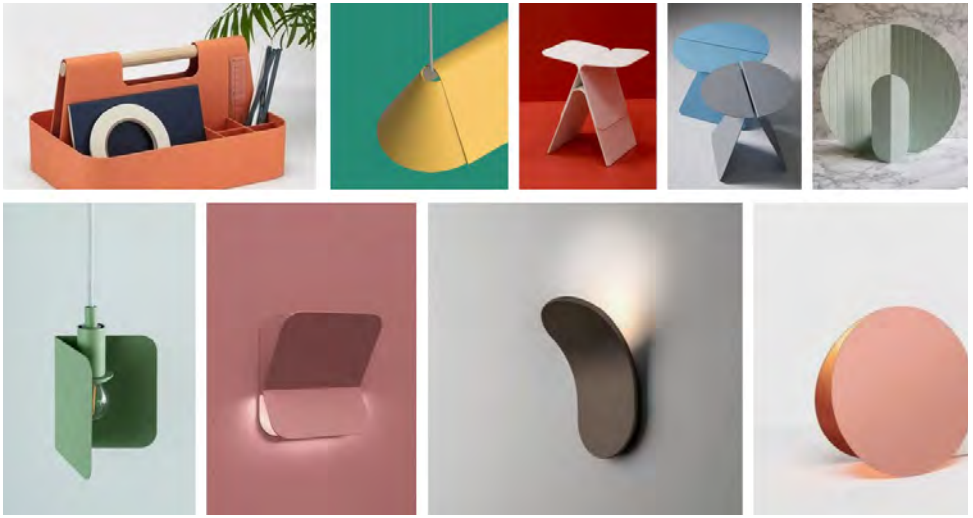


Figure 78: Part of the ‚steel' moodboard

To obtain more specific information about the properties and costs of the material, the project was consulted with an expert of Kimla company, specializing in the production of sheet metal machinery.

The expert confirmed that the best way to cut out the lamps' shells is to use CNC laser cutters. He recommended two types of metal: aluminum and DC01 steel. Due to its properties and above all higher softness, aluminum would have to be a minimum of 3 mm to be sufficiently rigid. However, steel, a stiffer material, would do its job even at a thickness of 1 mm. Finally, the expert-recommended steel for further development and price estimation.

Figure 79: Kimla headquarter

Considering that 1 m^2 of 1 mm thick DC01 steel weights around 8 kg costs around 5,5 € at wholesale price, and CNC cutting product weights around 460g, it gives 0,3 € per cut unit + price for CNC cutting. However, Slamp has the ability to cut thin metal sheets on their CNC machines.

PMMA

Another highlighted material is gradient, satin acrylic sheets (PMMA) Acrylic itself, same as steel, which is widely available. It is hard and stiff. PMMA has great UV weather resistance. Importantly, it is recyclable.

Plastic like PMMA and its processing fits perfectly with Slamp's manufacturing capabilities. The use of such material would not force the company to invest in additional production machinery. Moreover, a gradient can also be created using digital printing, a processing method that Slamp also uses.

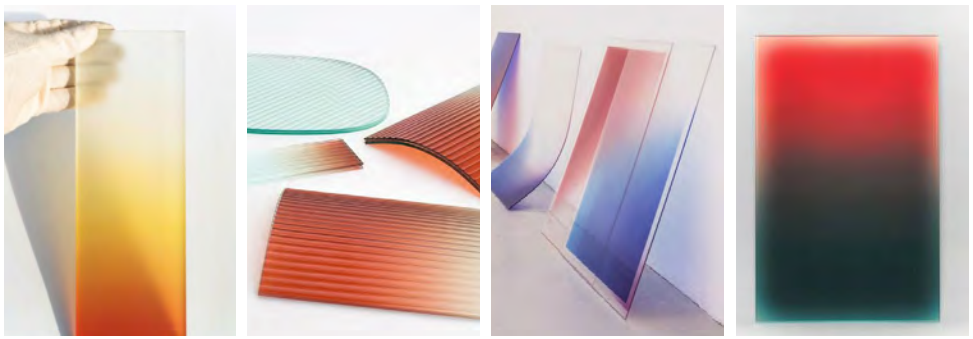


Figure 80: Examples of PMMA gradients

The gradient is interesting because, apart from aesthetic values, it also gives the lamp greater functionality. Thanks to the shell made of such material, with a darker color, on the top, it is possible to hide the components responsible for the operation of the lamp, battery, lighting source, etc.. In contrast, the transparent color is used at the bottom. As a result, the lamp used e.g., on a table, illuminates a larger area, also the sides of the lamp.

To evaluate the material's performance in reality, due to the lack of available products and suppliers of similar materials, provisional prototypes were made. The prototype was cut out by hand out of transparent plexiglass and then spray painted to give a characteristic gradient (*Figure 81*).

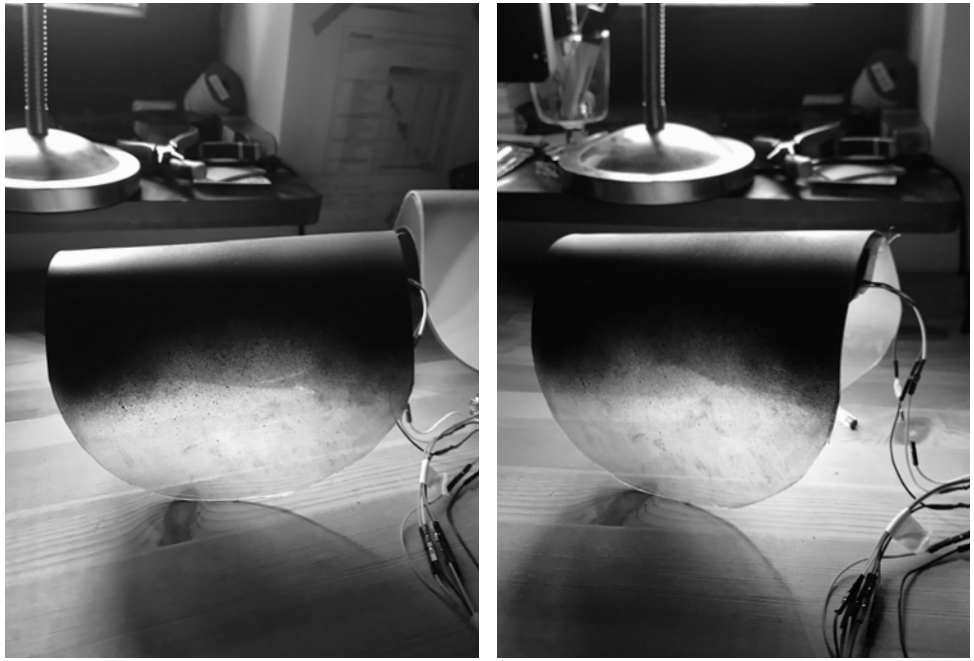


Figure 81: Provisional prototype

To achieve more reliable results, it was decided to buy a 3 mm acrylic plate from which subsequent lamp shells were laser cut, heated with a heat gun and bent on a previously prepared structure. Then they were spray painted.

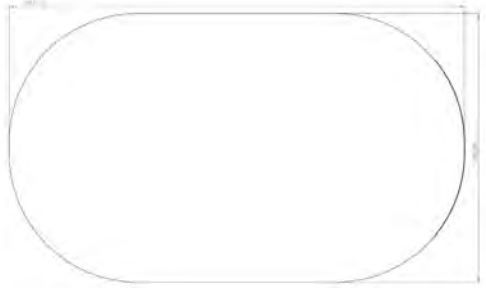


Figure 82: File prepared for laser cutting

The new prototype, with a dark gradient, worked perfectly. It ideally covered the components inside the lamp, while allowing the light to escape from the sides (*Figure 83*). Importantly, the sidelight did not adversely affect the characteristic light streaks made by the lamp.

Figure 83: Upgraded prototype

A prototype with a white gradient was also made. However, the paint was not sufficiently opaque, and after switching the light on, no gradient effect was obtained.

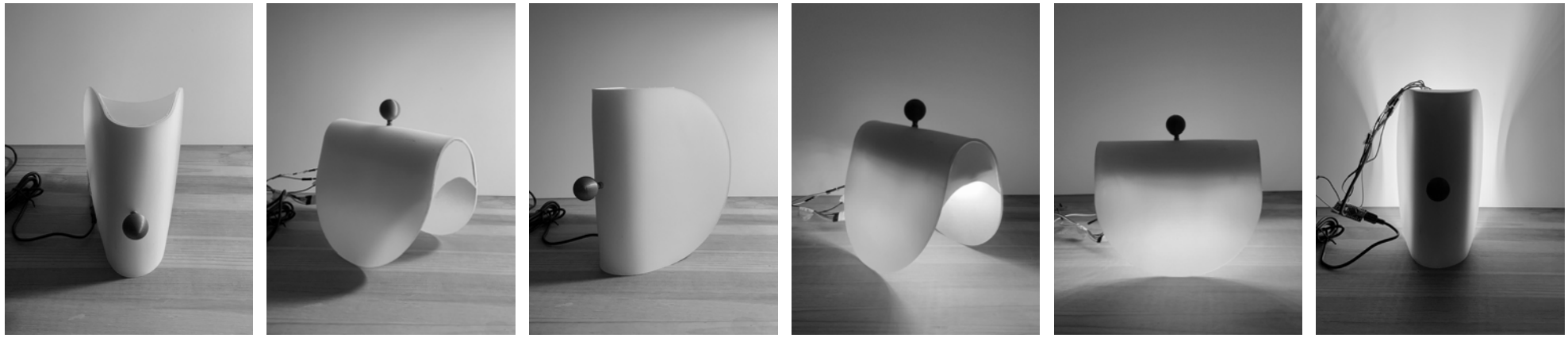


Figure 84: White prototype

Lighting Technology

The function dictates the choice of light technology that the lamp must fulfill. After determining that the lamp will be wireless, portable, and equipped with light intensity and color temperature adjustments, the choice was obvious, LED technology.

LED technology

Most importantly, for portable and outdoor use lamps, LEDs are a very reliable and durable form of lighting. Diodes operate in extreme atmospheric conditions and are much more vibrations and impact-resistant than other light bulbs. The components of an LED and the way they generate light, significantly extend its lifespan. Because of their high lumen output per watt, they are super energy efficient.

LEDs appear in various configurations and fixtures like strips or rings. It gives certain flexibility and design freedom. The LED strip can be bent and cut for length and shape that is needed.

While incandescent bulbs require various filters to create different colors and temperatures of light, the RGB LED offers an infinite number of shades and colors that can be changed using controllers.[28]

Dynamic White LEDs

Initially, the RGB diode was considered. However, after consulting with Slamp, Dynamic White LEDs were selected. Compared to RGB LEDs, which offer a virtually unlimited range of colors, Dynamic White LEDs (or Dynamic Tunable White LIghting) can control a light source's color temperature output from 2600K to 6500K. Furthermore, this type of LED technology is characterized by high CRI (Color Rendering Index) above 90. The brightness depends on the color temperature:

- Cool white + warm white = 1280 lm,
- warm white 2800 K = 600 lm
- cool white 6300 K = 690 lm

Dynamic White LEDs most usually appear in the form of LED strips, so it can be cut to the appropriate lengths and adapted to the chosen application. [29]

Figure 85: Dynamic White LEDs

Powering

An essential element of the wireless lamp is the battery, power supply, and charging method. The first and most important choice was the type of power supply. Three options were considered: replaceable batteries, solar power cells (with battery inside), and build-in batteries.

Replacable batteries

Replaceable batteries (for instance, AA) have gained popularity, especially in products that consume a small amount of energy such as children's toys, TV remote controls, or even flashlights, which are used from time to time. The use of this type of power supply in the designed product, due to the relatively large electricity demand of the selected LEDs, would force the user to change the battery too often, translating into high operating costs. Furthermore, the use of replaceable batteries, such as typical AA batteries, for a product that requires rather a large amount of energy has a critical impact on the environment, because their frequent replacement [30]

Figure 86: Example of replacable batteries

Solar panels

Solar panels seem to be a great solution. A user does not have to worry about charging. It is a renewable type of energy. After daylight exposure to the sun, the solars will accumulate enough energy to spend the evening in a lit light. Furthermore, panels are getting cheaper and easy to implement. However, this technology also has some disadvantages. It is not as sustainable as people think it is. The truth is that they make pollution and energy consumption during their manufacturing process, and they are likely to produce more while they get disposed. [31] Additionally, in the case of a wireless lamp, to store the acquired energy, an additional battery is needed, which will also be disposed of. Another downside is the aesthetic aspect. Solar panels have to be exposed to light to generate electricity. It is difficult to integrate panels into form and, at the same time, make a product looks appealing. Furthermore, the use of panels often takes away from the product, the impression of orderliness, and high quality. Besides, the designed lamp, despite adaptation to external atmospheric conditions, will also be used and probably most often stored inside the buildings, where often there is insufficient access to sunlight.

Figure 87: Solar panel with a bulb

Build-in Batteries

Build-in batteries are the most commonly used in products with similar applications of competing companies such as Artemide or Vibia. They are characterized by universality and convenience of use. Build-in batteries are very popular among lamp manufacturers because they allow users to easily recharge lamps, which is quickly discharge when used frequently. In addition, compared to AA batteries, it is easier for a manufacturer to ensure that they are hermetically sealed and prevent leaks. There are also some disadvantages to using them. Each battery will age after a while, and their performance will decrease. However, in the case of Li-ion batteries, it is possible to inhibit this process by so-called protection circuits, which limits the peak voltage of each cell during charge and prevents the cell voltage from dropping too low on discharge. [32]

Figure 88: Portable lamp with build-in battery

Types of Build-in Batteries

There are many types of batteries on the market. For example:

- Lead-Acid battery - most economical one, but for the applications where weight is a little concern.
- Nickel Cadmium (NiCd) - well understood, relatively low in energy density. It consists of toxic metals and is environmentally unfriendly.
- Nickel-Metal Hydride (NiMH) - higher energy density compared to the NiCd but reduced cycle life
- Lithium-Ion (Li-ion) - used in the application where high-energy density and lightweight are important. The protection circuit is important to ensure safety. [33]

The obvious choice for a project is to use Lithium-Ion (Li-ion) battery. They are widely used in this kind of application, portable lamps, mobile devices, laptops, and many others. The most important advantages of Li-ion batteries are above all high energy density. Besides, it has a much lower self-discharge rate than other batteries, e.g., NiCd or NiMH. Furthermore, Li-ion batteries do not require maintenance to ensure high performance. It is also important that there are plenty of types of Lithium-Ion batteries. Some have high current density; some provide much higher current levels. They come in many sizes and shapes, which makes them suitable for an infinite number of applications. [34]

Figure 89: Li-Ion batteries

Charging

Cable Charging

For the average user, charging is definitely more important than the type of battery used inside the lamp. **Still, the most common way to charge portable lamps is cable charging.** The most popular plug is micro USB, which is increasingly displaced for its younger replacement USB type C.

The only reasonable place for the input placement is inside the lamp (*Figure 90*). If it were either side, the cable would block the lamp from being placed on the side with the input when charging. However, if it was placed on the top, an input cover would be mandatory to ensure the lamp's tightness. It would negatively affect the appearance of the lamp.

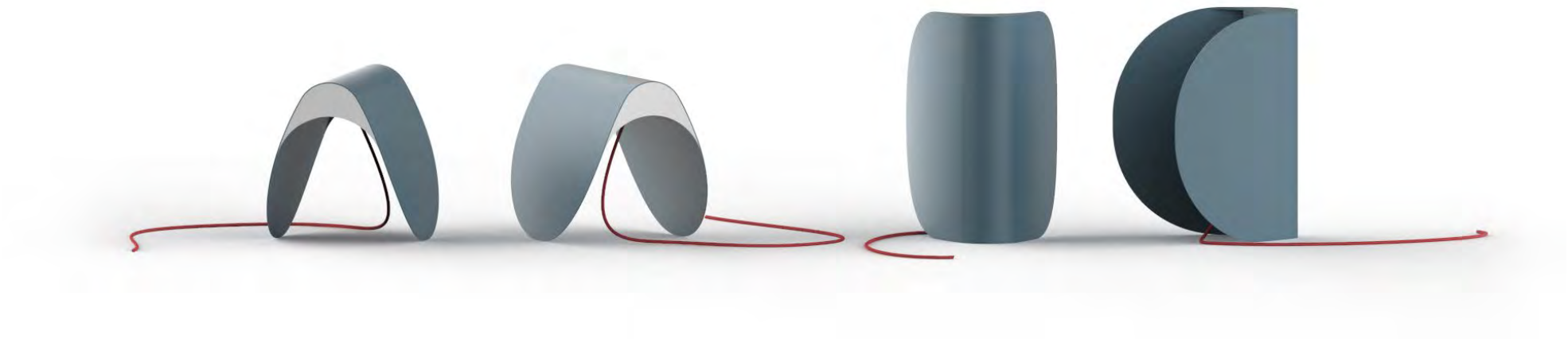
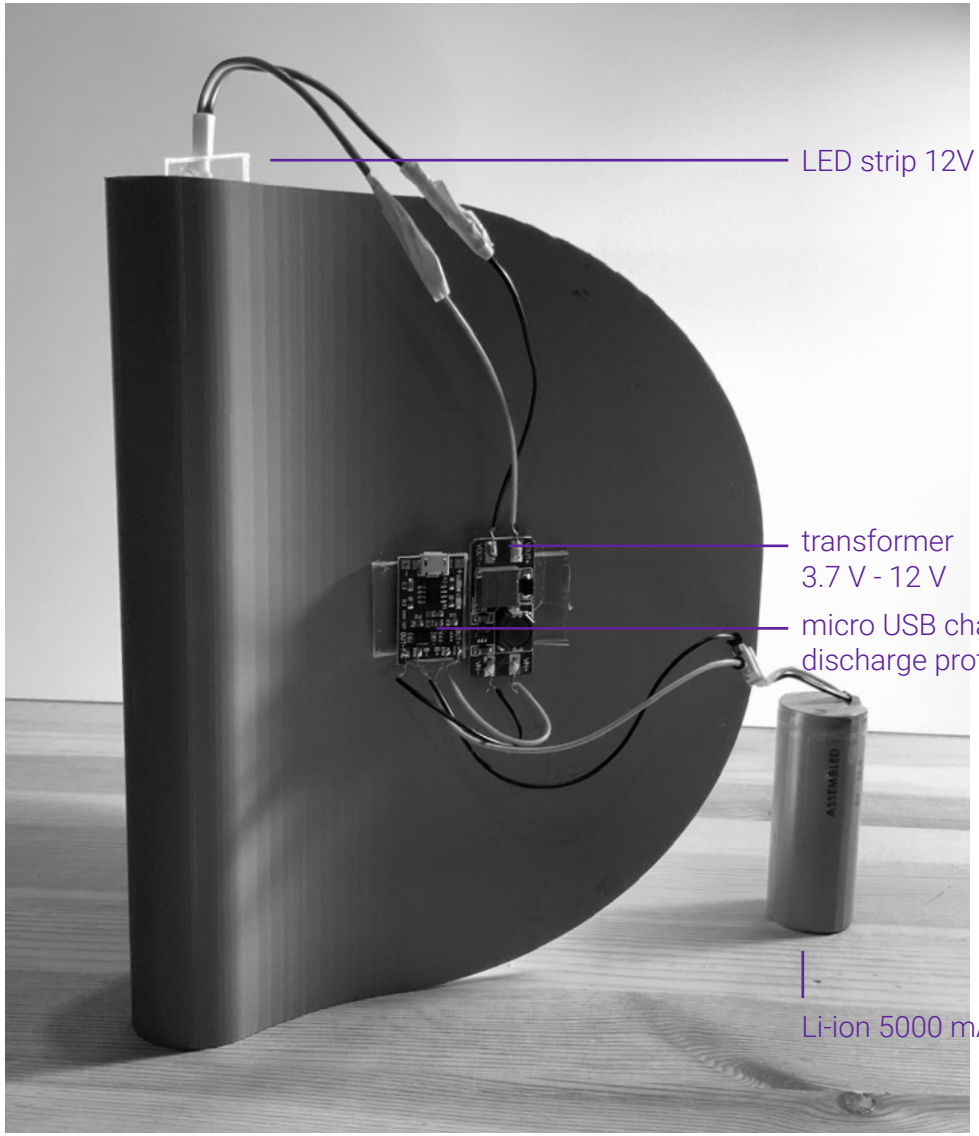


Figure 90: Lamp with charging cable

A working prototype of the charging system was made. The system consists of a 3.7 V, 5000mAh, LI-ion battery from Slamp's Clizia lamp. It was necessary to use a step-up transformer to power the 12V LED strip. The system was supplemented with a charging module with USB C input and discharge protection.



Wireless Charging

Wireless charging was also considered. The charging base has been designed for this purpose. At home, the lamp functions as a unity with the base, however, if necessary, the user takes the lamp itself outside.

Figure 91: 3D printed model with charging base

In addition, the lamp must be equipped with wireless charging modules. Upper part provided with receiver, base with transmitter.

Figure 92: Wireless charging receiver and transmitter

Following Slamp's suggestion, propositions of charging stands for three lamps were also introduced. Lamps on a stand, in the home space, create a floor lamp. If necessary, each module can be removed from the stand and used to create an external illumination system.

Figure 93: Examples of charging stands

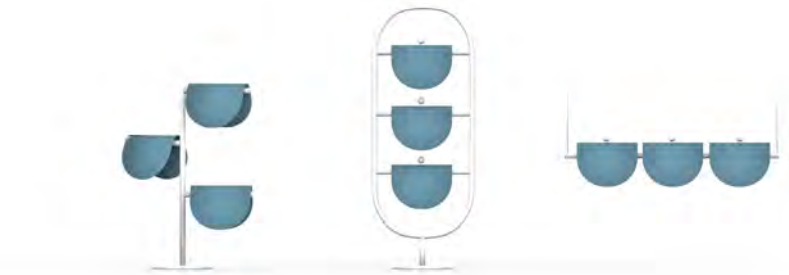


Figure 94: Second version of charging stands

Diffusers

An essential element, especially of the portable lamp is the light diffuser. To diffuse or scatter light in a manner to transmit softer illumination, there was a need to use such an element. Diffused light can be achieved by reflecting the light form, for instance, a white surface. However, if we are looking for more compact solutions, a better alternative may be ground glass, opal glass greyed glass, and their equivalents made of plastics. [35]

Considering the product's design characteristics, exposure to shocks and vibrations, plastics, for example, PMMA acrylic sheets, is a better solution. Many matt and satin materials on the market differ in transparency and light transmission. Desk research of unusual structural diffusers was also carried out. Interesting alternatives are products such as Optical Micro Prism by IO GmbH & Co. KG or Prism Commodities by Jungbecker.

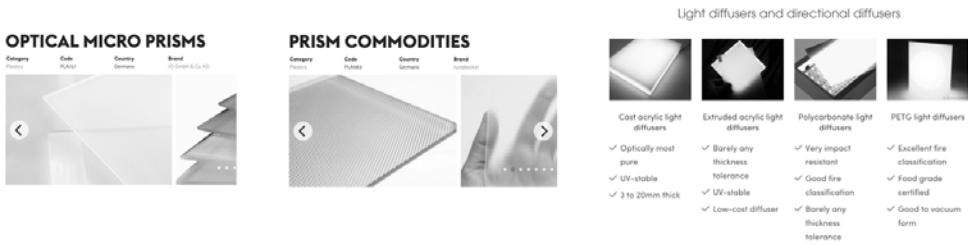


Figure 95: Examples of light diffusers

A great solution is also the diffuser patented by Slamp, widely used in their projects. The material is transparent, flaccid, thin but has a crinkle-cut structure. By imposing individual layers of material on each other, you can freely direct and scatter the light depending on the chosen angle.

An experiment was carried out. The material was cut into strips at different angles of texture orientation. Individual strips were then shuffled to obtain the most even and diffused light.

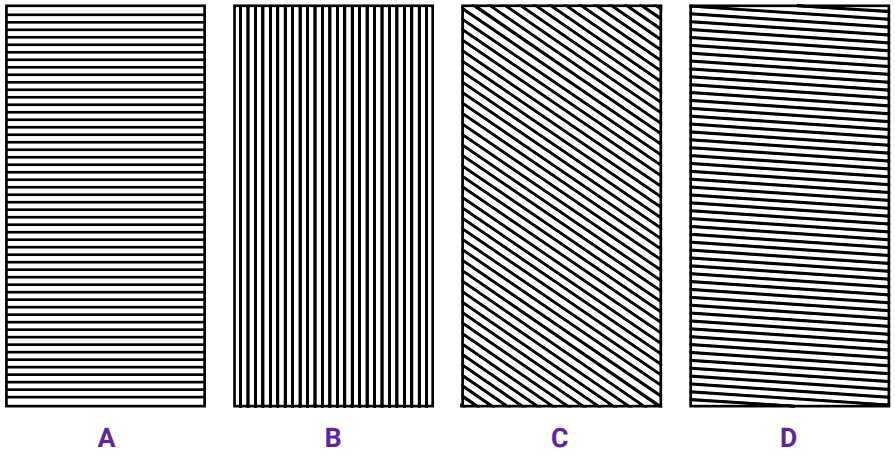


Figure 96: The elements cut out from the Slamp's diffuser

The configuration that turned out to be the best consists of 3 strips: A, B, and C superimposed.

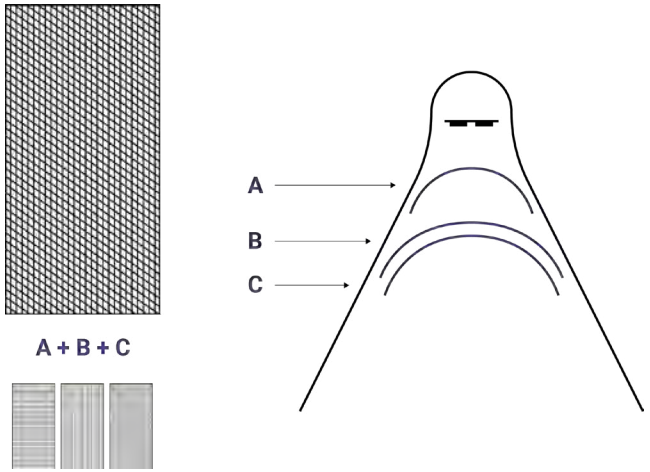


Figure 97: The best combination of diffusers

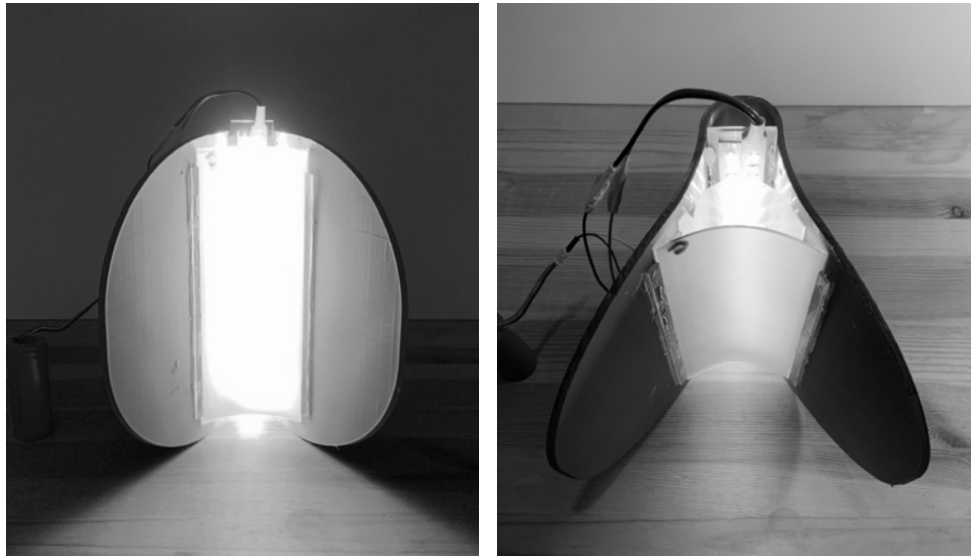


Figure 98: Final result

The scenario of using wireless charging was also considered. Then it is necessary to install the panel in the inside of the lamp under which the charging base could be placed. The prototype was made; however, it turned out that through the gaps on the sides of the inner panel, too little amount of light is transmitted.

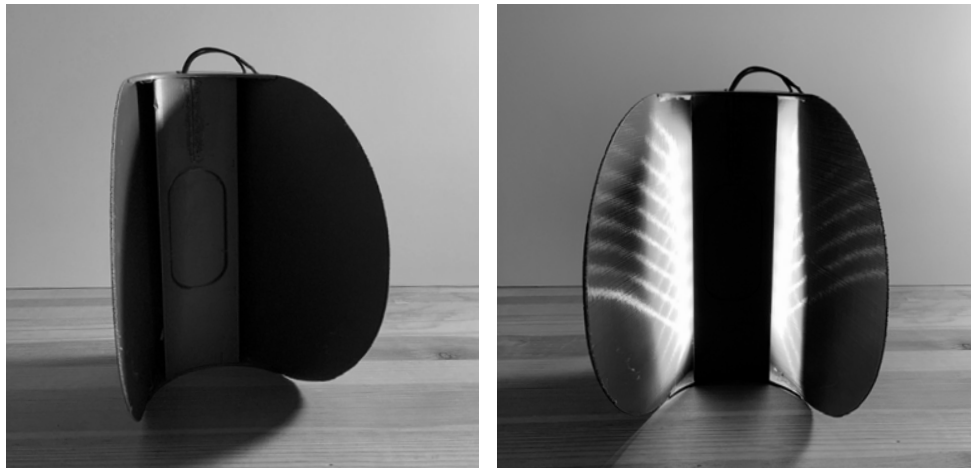


Figure 99: Prototype with the charging panel inside

In order to transmit more light, another prototype was made. The panel inside was replaced with bent plexiglass, which in the middle, where the receiver will be located, was covered with opaque paint. The results were much better. Thanks to the new solution, the lighting was clearly brighter.

Figure 100: Second version of the panel

Light Qualities Control

Reflections on light qualities control were resumed. Instead of an encoder on the top of the lamp, a capacitive touch slider was integrated into the form. An interaction (*Figure 101)* was designed, and subsequently, a simple experiment was carried out. Unfortunately, it turned out that using the touch slider on the back is entirely unreasonable and requires two hands. The lamp, through its circular shape, is swaying when trying to change the properties of light.

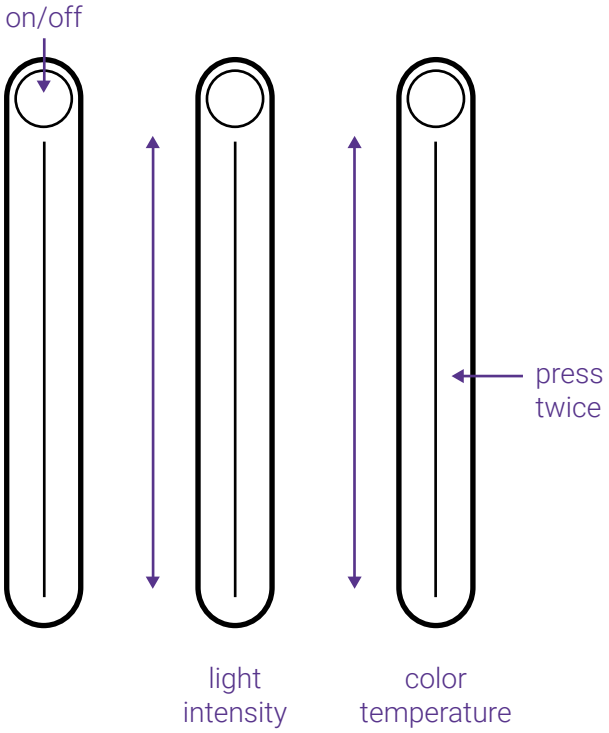


Figure 101: Capacitive slider interaction

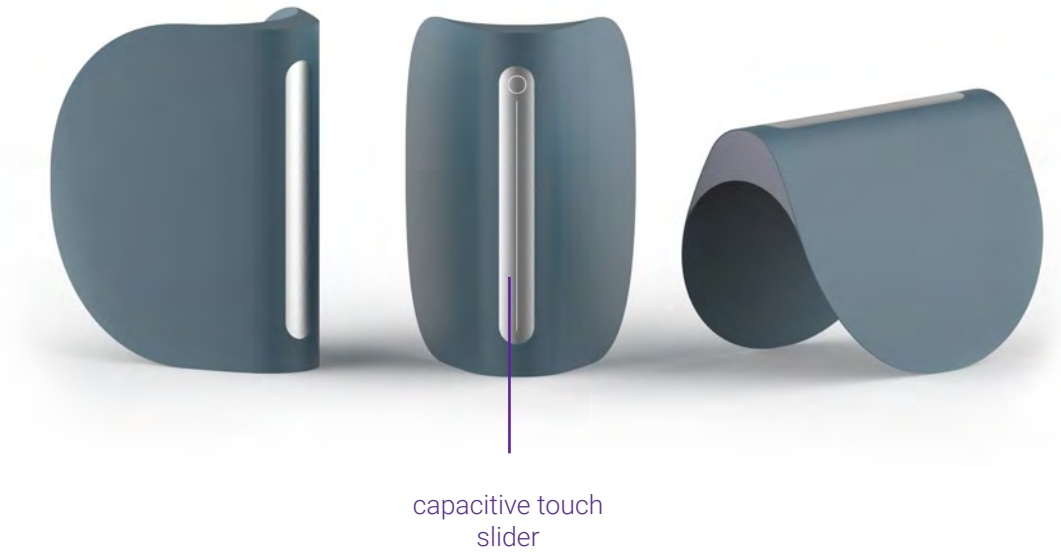


Figure 102: Render of the product with capacitive slider

After the unsuccessful idea of using a capacitive touch slider, the encoder version development has returned. At first, attempts were made to rethink the appearance of the dial itself. To this end, a series of different types of knobs were created and placed on the lamp's top.

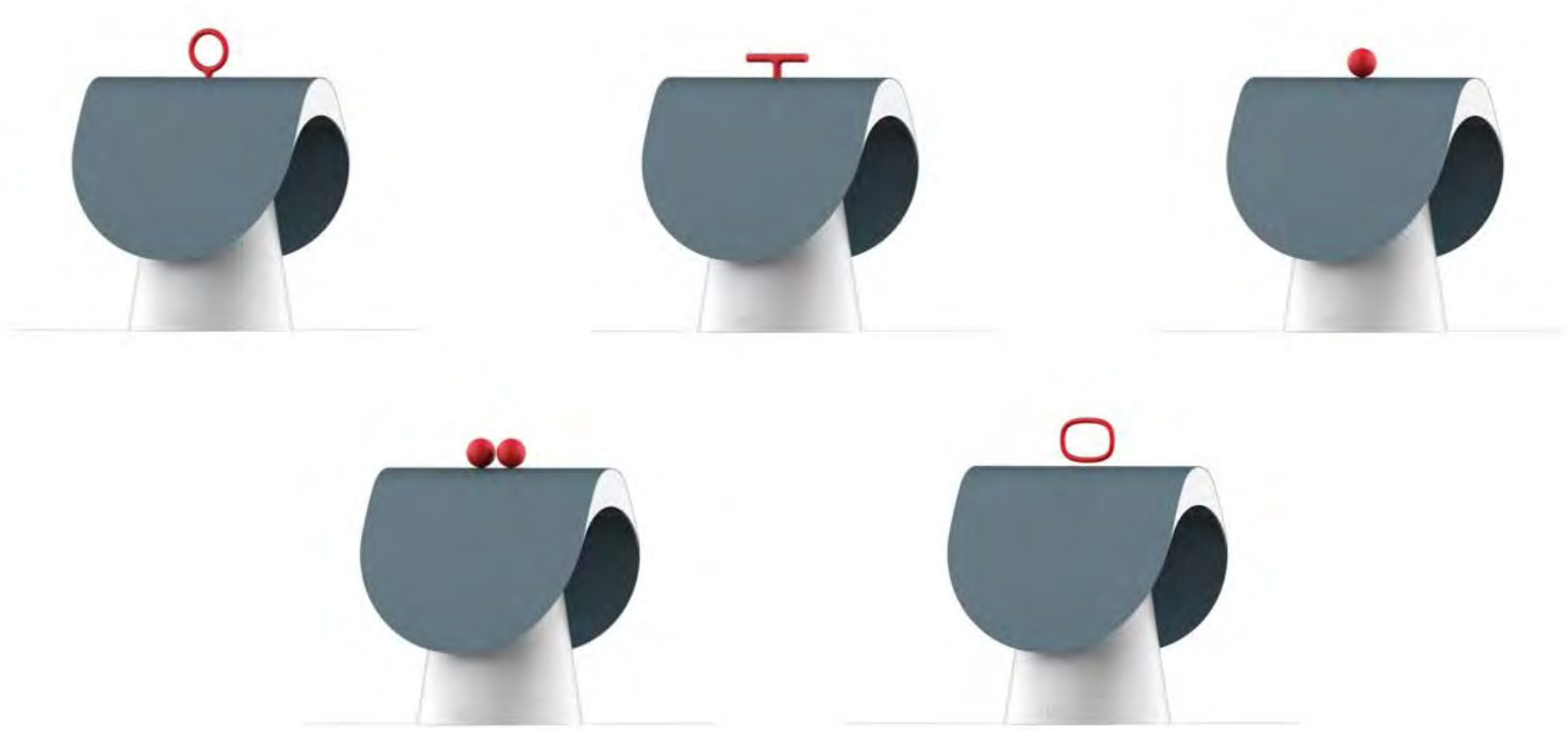


Figure 103: Series of various knob designs

Once again attempts were made to refer to women's purses. Options with two knobs referring to the famous Burberry purse, were proposed, but finally it was decided that using one knob is definitely more functional.

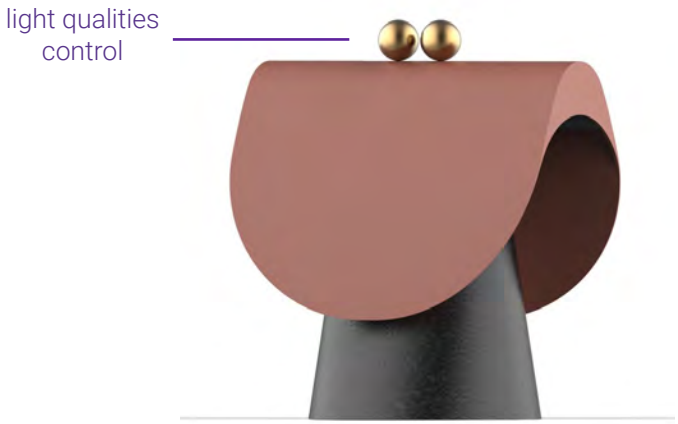


Figure 104: Lamp inspired by Burberry purse

Finally, a fully functional interaction prototype, with one knob, was made using Arduino Nano, encoder module, and 5V RGB strips. Details such as the effect of smooth turning the light on and off were also taken care of.

Figure 105: Fully functional interaction prototype

Angle Adjusting Mechanism

In order to increase the playfulness of the lamp, consideration was to create an angle adjusting mechanism. Thanks to such a system and its standard operating positions, the lamp could also be used at intermediate angles.

Initially, work was carried out on the external element, which would be both a decorative element of the lamp and a weight, which would outweigh the lamp to the right angle.

Another approach was to try to hide the angle adjusting mechanism in the center of the lamp. Two ideas were highlighted, the use of sand as a counterweight and the use of an element that anyways must be inside and is the heaviest battery. The concept was to create a tunnel with two small air outlets at the ends to allow air to escape and the battery to move. However, this would involve considerable risk and an increased probability of damage to the battery.

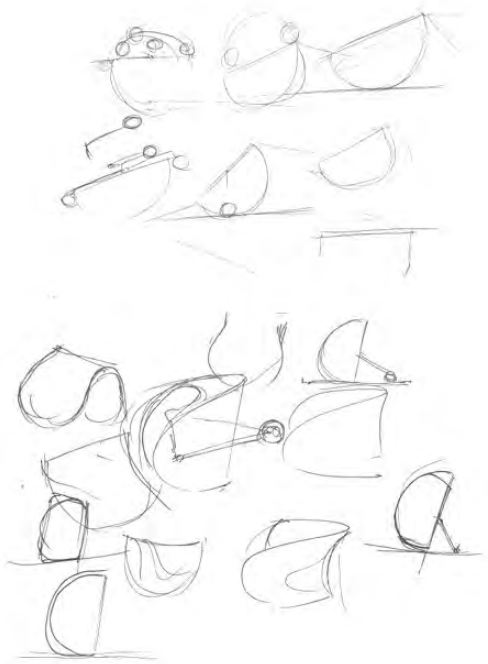


Figure 106: Sketches of the angle adjusting mechanism

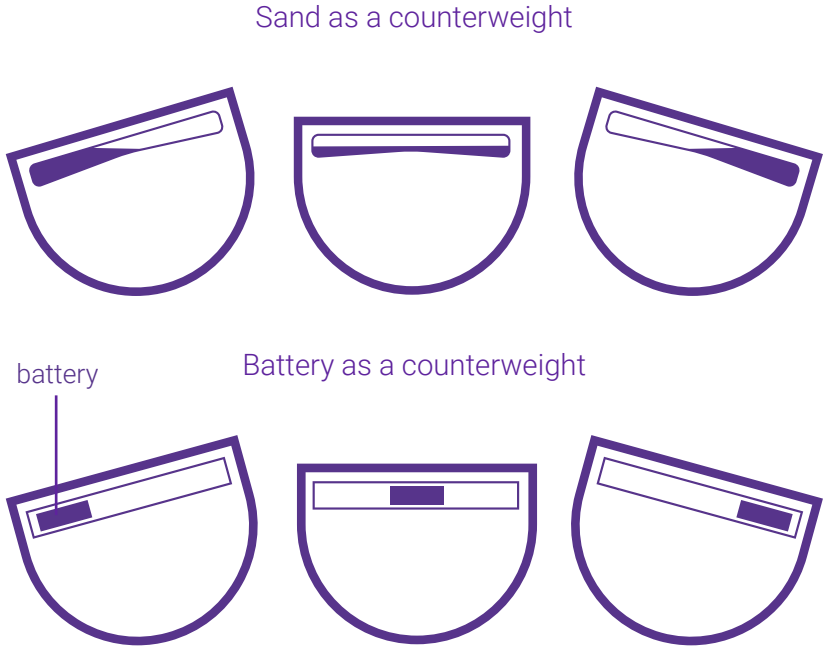


Figure 107: The angle adjusting mechanism directions

Final choices

The detailing stage was aimed at isolating individual components of the lamp and searching for technical solutions for each of the subcategories. This was done to expand the technical knowledge necessary before starting the embodiment design phase. However, before beginning the next stage, once again, it was essential to converge the acquired information and choose the most appropriate solutions for the project.

Size and Shape

Due to the appearance - clean, straightforward shape and production capabilities of Slamp, it was decided to further develop the simplified form of the lamp.

Materials Selection

Due to the chosen form, no decision was made to select a specific material. Therefore, two types of material were selected - steel and PMMA, which will be developed simultaneously. The selection decision may be postponed to a later stage as the material acts as the outer casing and can be replaced regardless of the internal components.

Lighting Technology

LEDs were chosen as the lighting technologies, which are undoubtedly best suited for this type of application.

Charging and Powering

It was decided to use two types of charging. Traditional cable charging and wireless charging. Thanks to this, the user buying one lamp will be able to charge it with a cable, while the user with three lamps and a stand will be able to charge wirelessly. The product will be powered by built-in Li-ion batteries.

Diffusers

The choice of the diffuser had to be moved to the next stage due to the lack of a specific inner casing design. Further diffuser trials will be carried out with more advanced prototypes.

Light qualities control

Light quality control will be performed with one knob. This solution is definitely more practical and easier to implement.

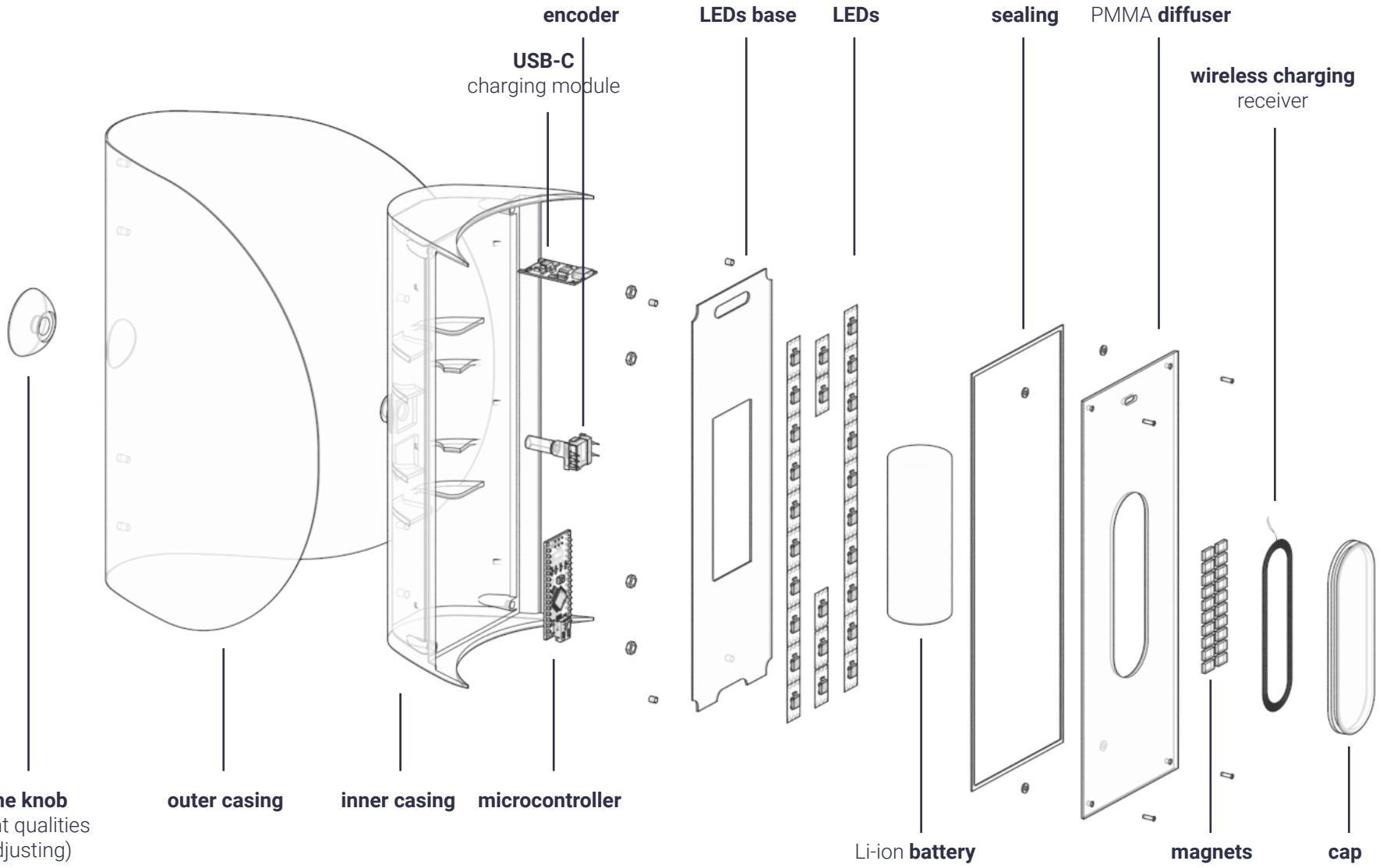
Angle Adjusting Mechanism

It was decided to reject the idea of implementing the angle adjusting mechanism. Admittedly, it would introduce an additional element of playfulness, but it would take place at the expense of complicated mechanisms which, apart from their dimensions, could be unreliable.

Embodiment Design

The detailing phase resulted in obtaining the necessary information necessary to start the embodiment design. Importantly, technical dilemmas were clarified, and components that will be used in the final design have been selected.

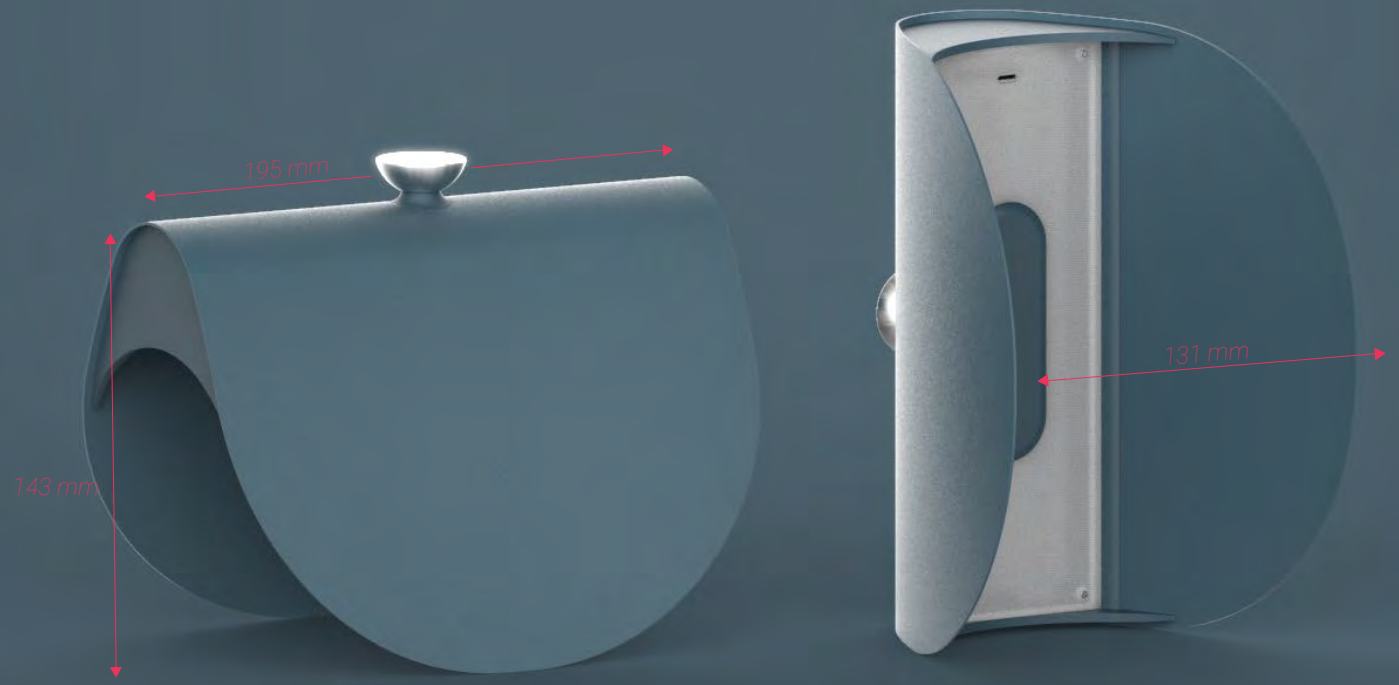
Exploded view



Casing

The critical aspects of the functioning of a portable lamp, intended for outdoor use, are durability and tightness. Therefore, great importance has been attached to the design of the external housing, which protects the internal electrical components against weather conditions, and above all, water.

The photo below shows a render of the final lamp model with an external housing made of stainless steel. **For the complete process and the rationale behind the decisions made, see Appendix B, C, D, E.**



Outer Casing

One of the most important elements of the lamp is the steel outer casing. To produce a module, firstly, metal elements are laser cut from a sheet of stainless steel and then bent with a press and suitable mold. Due to the simplicity of the shape, it is also possible to bend the modules by hand. Four threads are welded in the middle of the outer casing, making it possible to attach the inner casing.

Finally, the outer casings are powder coated, which protects the modules against scratches, weather conditions and gives a unique texture.

For more, see Appendix C and D.

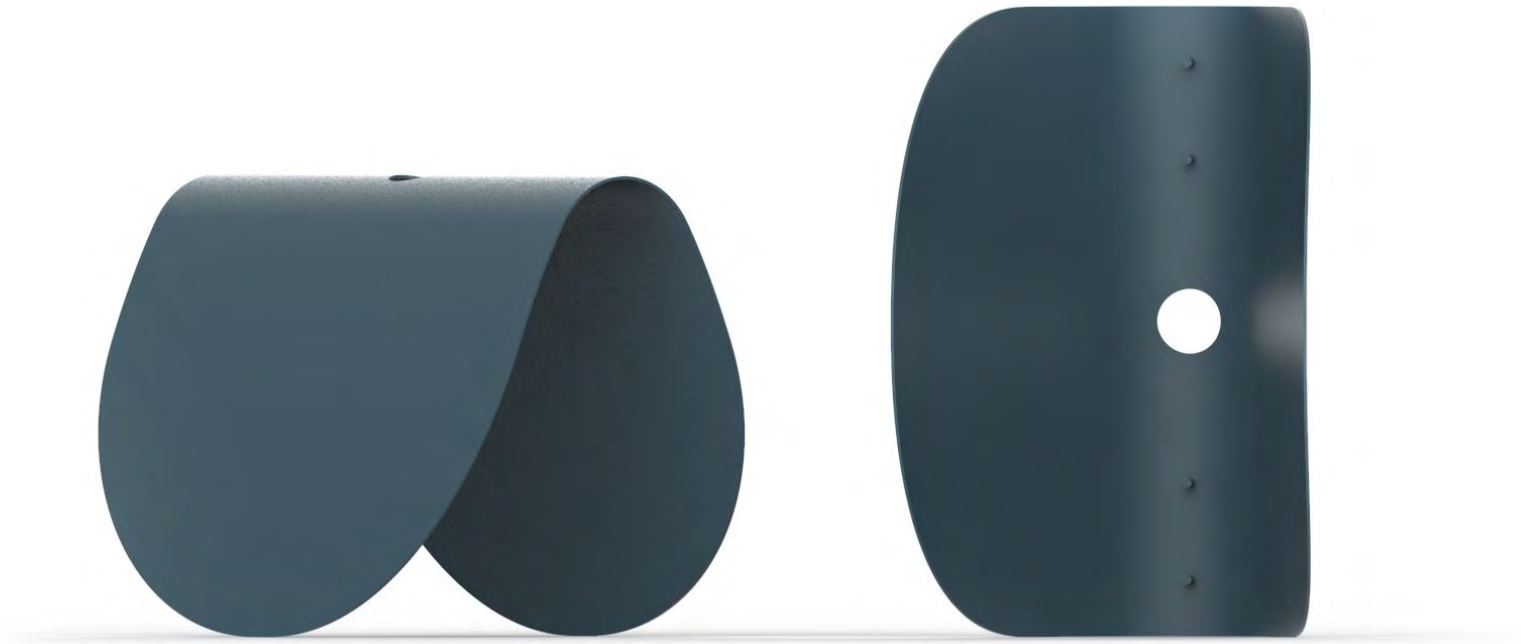


Figure 108: Picture of the outer casing

Inner casing

The inner casing ensures safety and protects all electrical components such as the battery, encoder, microcontroller, LEDs, etc. The module is manufactured by an injection molding method out of Polycarbonate, characterized by high durability and resistance to weather conditions. Importantly, it is a recyclable material.

The module has been designed with the elements positioning the encoder and the battery.

Figure 109: Picture of the inner casing

Inner and outer casings are connected by M3 nuts. The holes are additionally secured with rubber washers to ensure tightness.

Figure 110: Outer and Inner casings

The ‚chimney' for the knob is profiled in such a way as to create a smooth transition between the two elements.

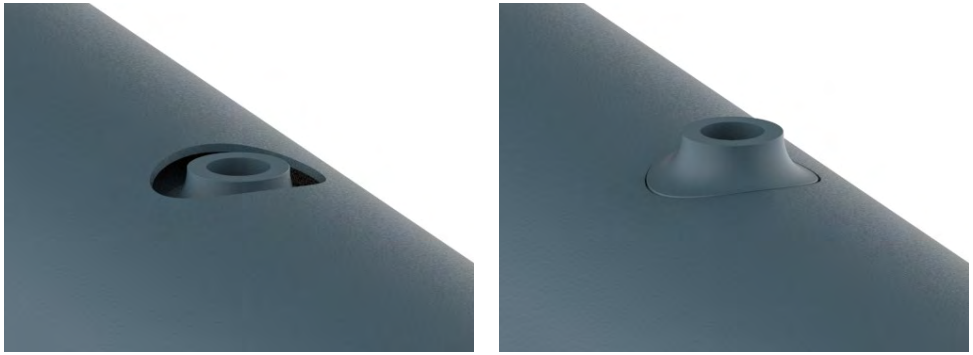


Figure 111: The ‚chimney'

The tightness of the inner casing is completed using a PMMA diffuser and a rubber cap. A silicone seal was applied between the diffuser and the inner module. The whole is tightened with M2.5 screws. It was necessary to use an element in the form of a rubber cap. It has several functions. First of all, it creates space inside the product for the wireless charging receiver and magnets. Secondly, the shape of the rubber cap makes it easier to position the lamp on the stand. The use of magnets strengthens the connection and gives the user feedback that the lamp is correctly positioned.

Figure 112: Exploded view of the inner casing

Figure 113: Sealed inner casing

Components

The inner casing is divided into two parts. The first part contains most electrical components, all cables, a microcontroller, an encoder, and a charging module with a USB-C port. The second part, separated from the first by the LEDs base, has mainly LEDs, magnets, and wireless charging receiver located in the front cap. The battery is located between two compartments.

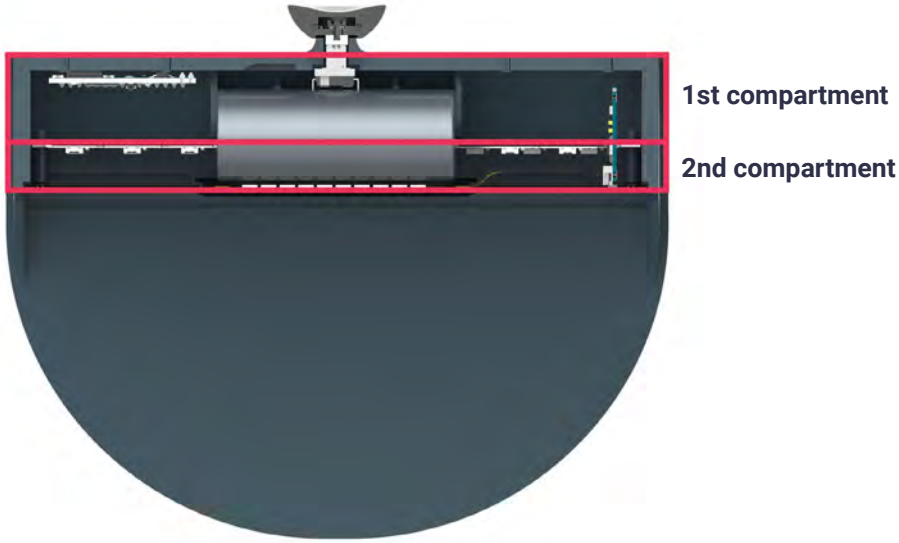


Figure 114: Cutaway view of the product

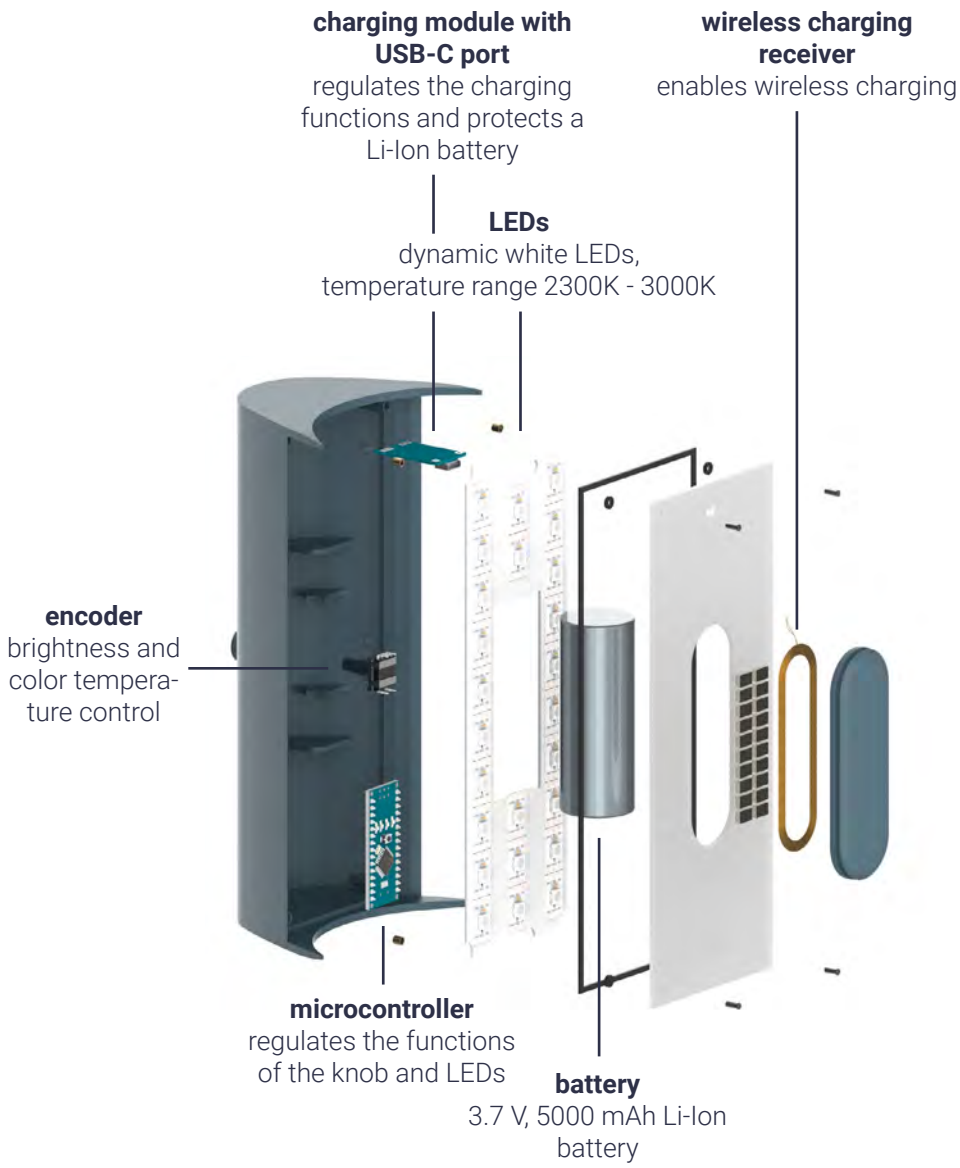


Figure 115: Exploded ciew of the inner casing with components

Knob

The knob turned out to be a significant design challenge. Many attempts have been made to find a form that fits stylistically into the minimalist form of outer casing [Appendix F]. The chosen version refers to the lower part of the lamp through the form of a semicircle. There is a delicate dent at the top, signaling the possibility of pressing the encoder. Realizing that the lamp can be lifted and carried by the knob, it was important to attach the knob to the encoder properly. For this purpose, the knob is divided into two parts. The lower part is attached to the encoder with an M2 screw, while the upper part acts as a blanking plug. The pierce line is just below the top edge, making it virtually invisible.

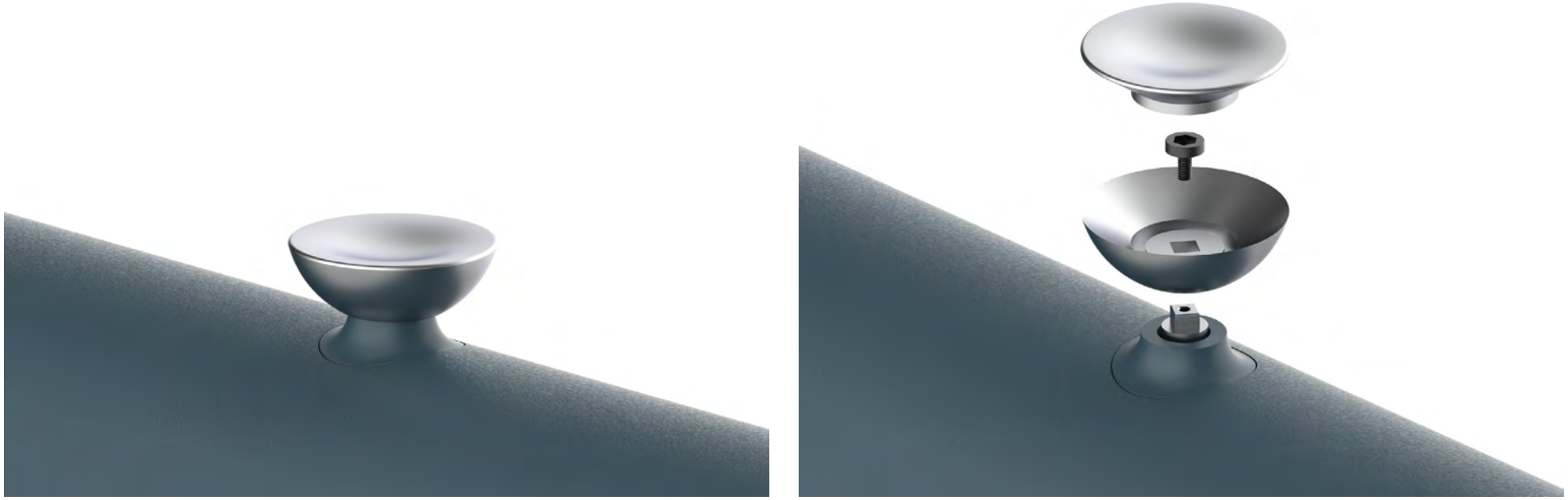


Figure 116: The knob design

Colors

The product can be painted and sold in a wide range of colors. Example:

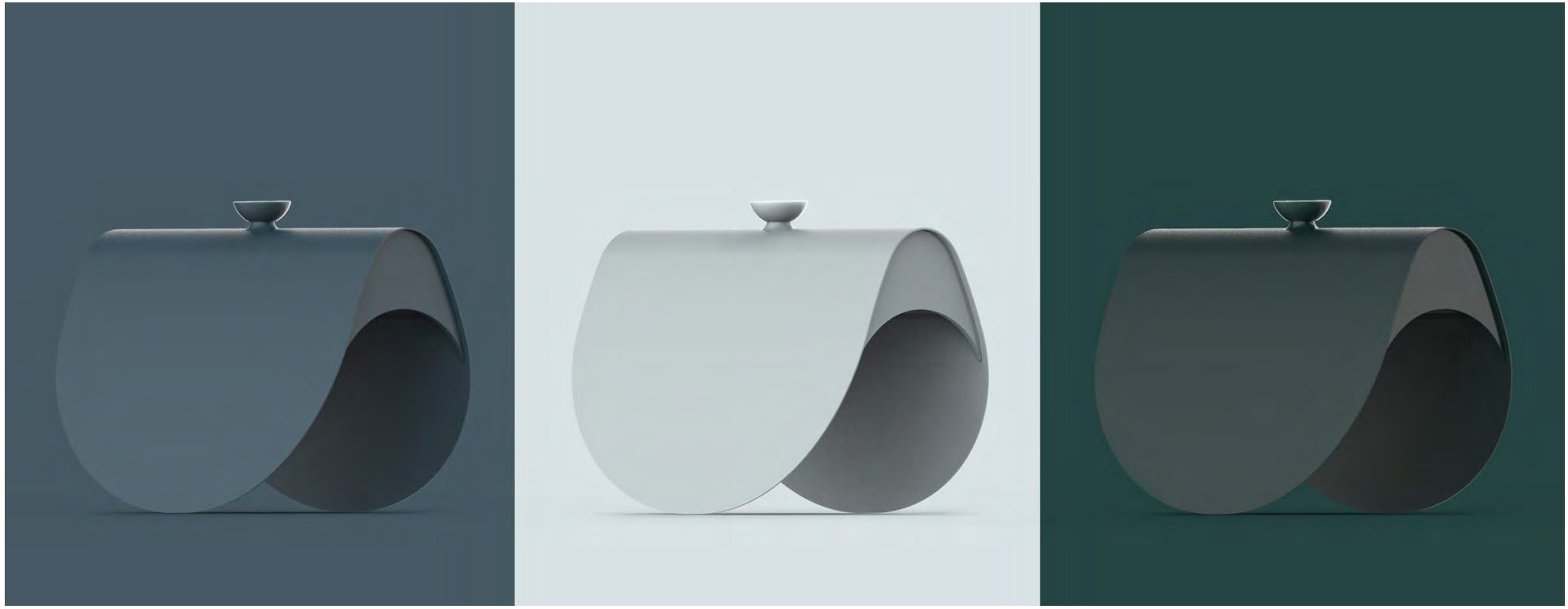


Figure 117: The product in various colors

Costs estimation

An approximate costs estimation of the investment, as well as the prices of individual components included in the designed product, was made. The cost estimation included external housing made of stainless steel.

The cost of the investment, i.e., the main prices of molds for injection molding and metal stamping, was estimated at 12,900 €. However, the cost of the components needed to produce one lamp is 36.55 €.

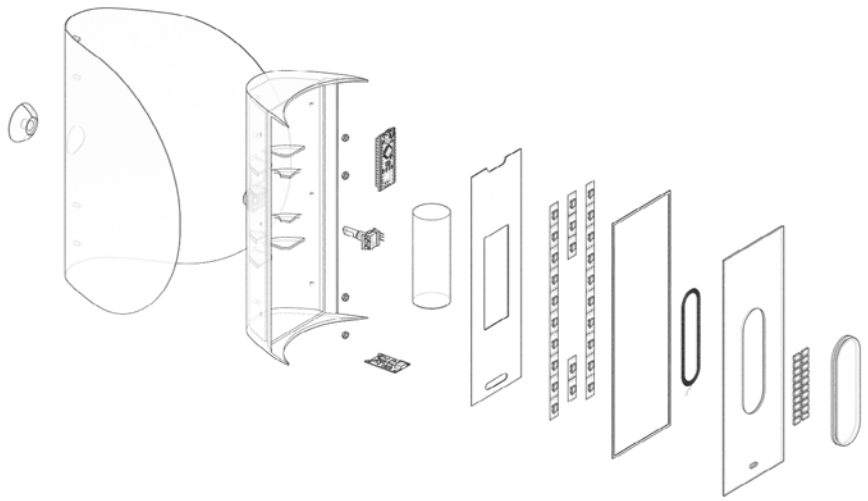
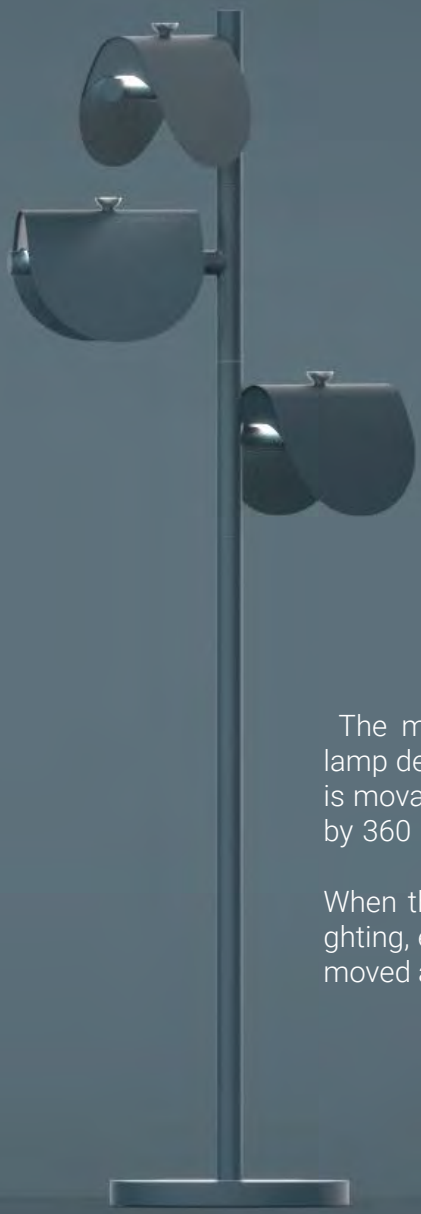


Figure 118: Exploded view of the product

	investments	per unit
outer casing (stainless steel + paint)	pressing mold **~ 2500 €**	**~ 4.5 €**
inner casing	injection molding mold **~ 6000 €**	**~ 3 €**
knob	lathe tooling **~ 400€**	**~ 8 €**
rubber cap	injection molding mold **~ 4000€**	**~ 1 €**
magnets	-	**~ 0,35 €**
sealings	-	**~ 0,40 €**
LEDs base	-	**~ 0,10 €**
diffuser	-	**~ 0,20 €**
electrical components	-	**~ 17 €**
total	**12 900 €**	**36,55 €**

Stand



There is no doubt that in order to create an atmosphere in a garden or on a terrace, it is worth having at least three lamps. Then one can be used on the table, while the other two can illuminate the surroundings. A user who decides to buy three lamps can additionally purchase a charging stand.

The modules on the stand form a standing lamp dedicated to home use. Each of the arms is movable so that each module can be rotated by 360 degrees according to the user's wishes.

When there is a need for additional outdoor lighting, each fully charged module can be easily moved and used outside.

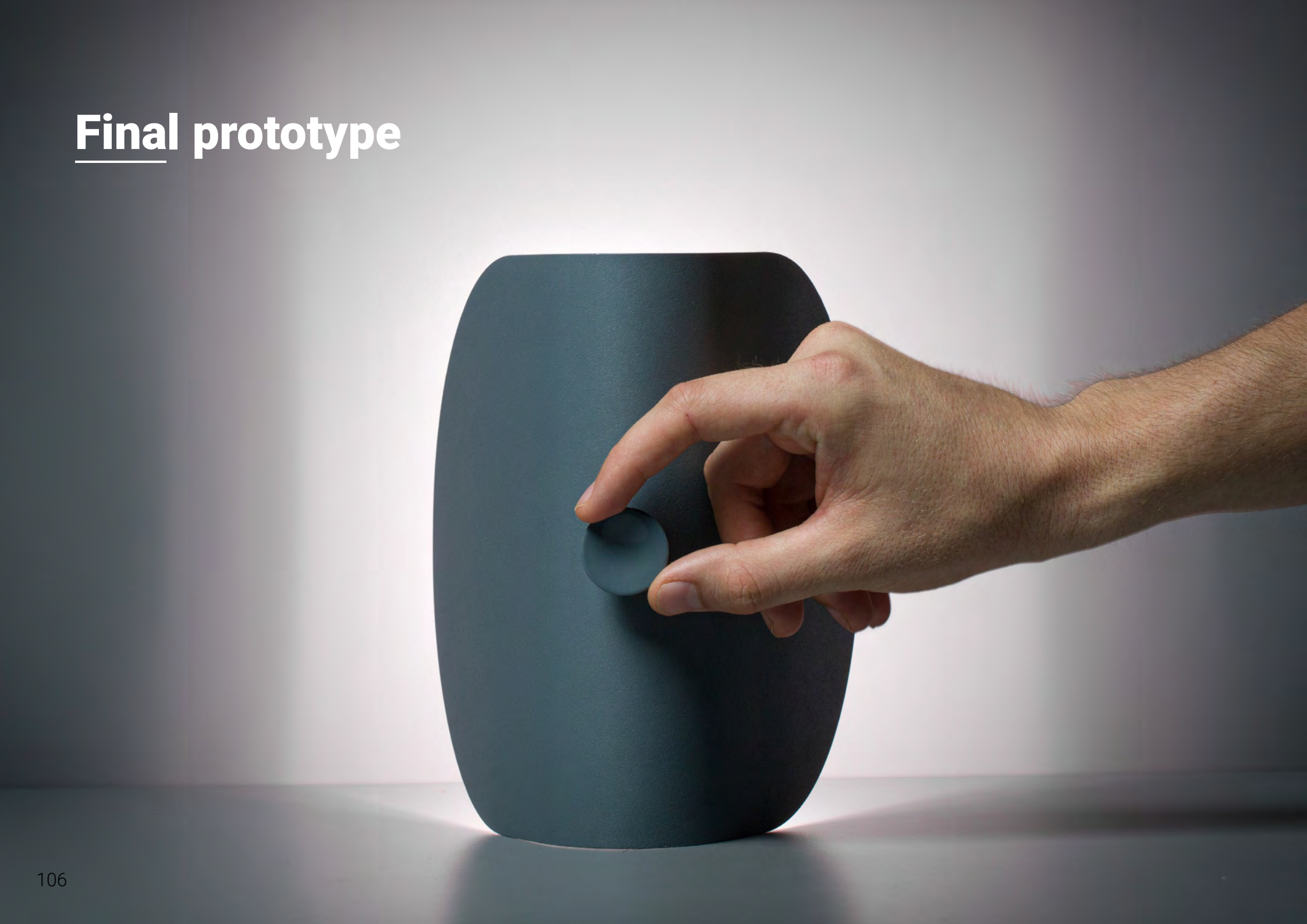
Each arm of the stand is equipped with wireless charging transmitters, thanks to which the charging experience is completely seamless for the user. The arms also have profiled positioning dents and magnets that keep the connection.

Final Prototype

After the embodiment design stage, the final prototype was created. In fact, the prototype was created at the embodiment design stage and is a consequence of many trials and corrections, 3d printing, material bending, and many others. Tremendous efforts have been made to ensure that the prototype is fully functional and fully reflects the design intent. Thanks to this, it will be possible to carry out a reliable test of the product among potential users.

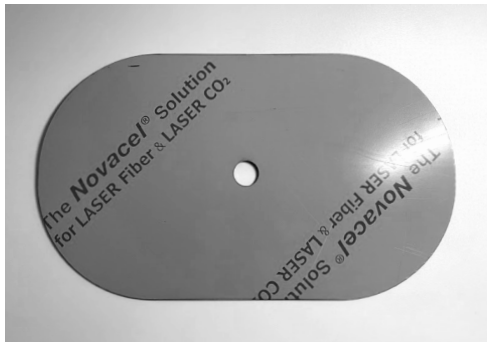
Finally, only the lamp module without the stand was intended for the prototype. The stand design was created at a relatively late stage of the project. It is an additional accessory and demonstration of the potential and versatility of the lamp.

Final prototype



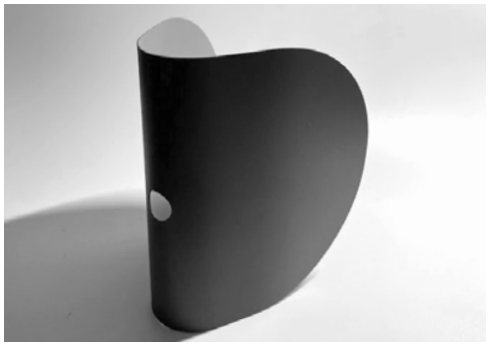
Casing

Due to the casing function, and that visually it is the most critical element of the lamp, the outer shell was made with the highest care. The work on the metal outer casing used in the final prototype is presented below. However, experiments have also been carried out on bending artificial materials, in particular PMMA. For this purpose, a unique form was made, see Appendix X.

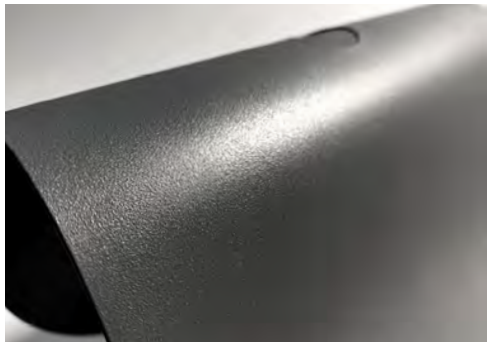


1. The modules were laser cut from a 1 mm thick sheet of stainless steel.

2. The modules were manually bent on a previously prepared structure with an appropriate beam radius. It required special attention and many trials because, due to the properties of the steel, it was easy to overpress and damage the module.



3. The bent modules were powder coated. This method perfectly protects steel against damage, weather conditions, and dirt. The chosen colors are RAL 7031 - gray with a hint of navy blue and RAL 7035 - light gray with a shade of green.



Along with the practical aspects, powder coating gives the products aesthetic value. In addition to color, you can choose from various textures and gloss grades.

4. The inner casing was printed on a 3D printer out of PLA. Contrary to the design introduced in the Embodiment Design chapter, for practical reasons - easier printing and fitting with the outer case, „the encoder chimney" has been printed separately.

5. The inner casing was then painted with a semi-matt acrylic paint RAL 7031. After drying, it was glued to the outer casing using epoxy glue.

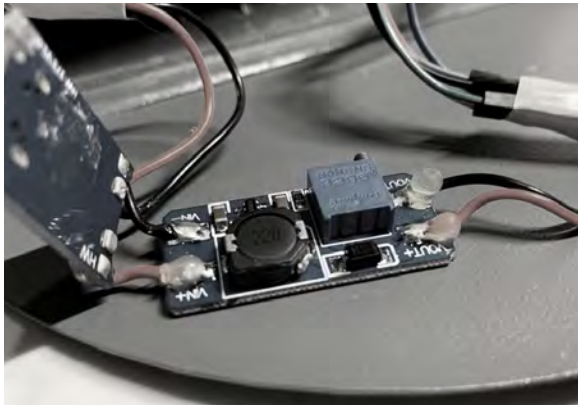
Components

After the housing was completed, the assembly of the previously prepared and programmed electrical system was installed inside. The circuit is made up of six components: LEDs, transformer, charging module, battery, Arduino Nano, and encoder. As at embodiment design, the inner casing is divided into two parts. ‘Dirty’ part with the majority of cables and electronic components and ‘clean, part with LEDs, battery, and charging module.

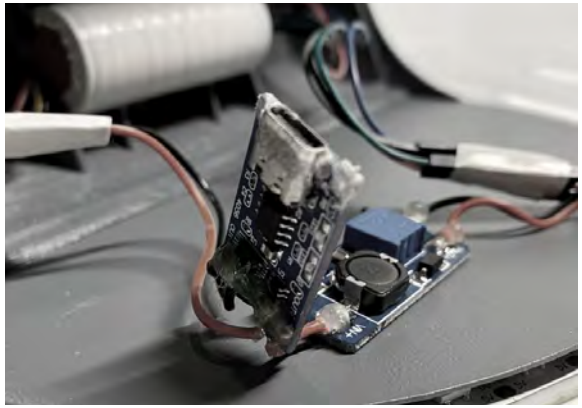
Some components proposed in embodiment design, for example, dynamic white LEDs have been replaced with substitutes for easier programming and implementation in a prototype. In this particular case, a programmable 5V LED strip was used. The strip can also be easily cut to smaller lengths, which is an additional advantage in small applications.

Figure 119: Pictures of the casing with components

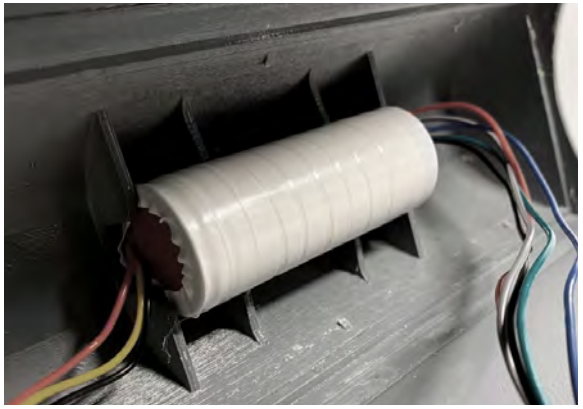
3. Programmable SMD 5050 SK6812 LED strip. 96 LEDs per meter. Luminus flux of LEDs is 208 lm.



3. MT3608 step-up converter 2V - 24V. To increase the battery voltage from 3.7V to 5V.



3. TP4056 Li-Ion charger module with a cell protection system and USB-C port.



6. 5000 mAh Li-Ion battery. The battery is currently being used in other Slamp's products.

6. Initially, the system was programmed on the Arduino UNO, but then it was moved to the smaller Arduino Nano. For the code, see Appendix X.

6. Rotary encoder with a button. Pulse circle - 30.

Finalizing

The diffuser and the base for the LEDs have been laser cut from PMMA and HIPS.

The knob was 3D printed and, just like the chimney, painted with RAL 7031 acrylic spray paint.

The knob was 3D printed and, just like the chimney, painted with RAL 7031 acrylic spray paint.

The final prototype.

Validation

In-home product validation was carried out to check the design assumptions with the result of the work and to confront the prototype of the final product with the target group. The method chosen for the tests was a combination of observations with an interview and a questionnaire in which the participants assessed their observations and experiences. [36]

Four couples took part in the in-home test. All people belonged to the target group: 40-50 y.o., middle income, stable living situation. Each couple owns a house with a garden or apartment with a terrace or balcony.

Figure 120: All participants of the validation

Validation took place in the place of residence of each couple during the evening hours. Therefore, it was possible to demonstrate the lamp's full potential and map the target environment and scenarios for which the lamp was designed.

Validation has been divided into six categories: Appearance, Convenience of carrying, Operation / UX, Scenarios, Light, Slamp Values.

Before the start of the test, participants were given a lamp instruction manual, consisting of an iconographic graphic on controlling the properties of light and an explanation of how to charge the cable.

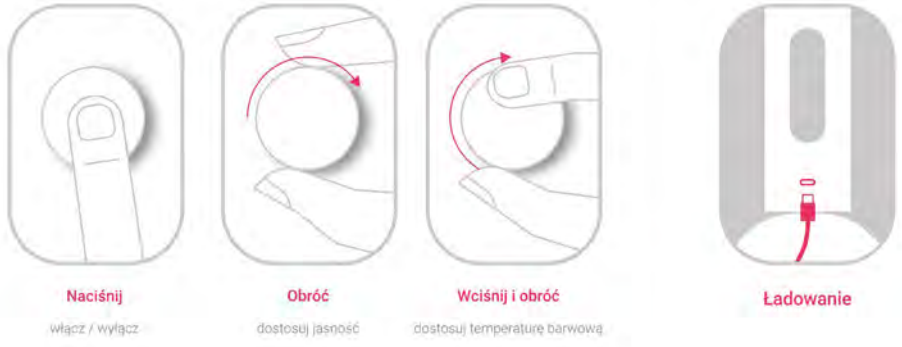


Figure 121: UX manual in Polish

The validation sheet consisted of two elements, the part for the researcher in which the remarks and observations of the participants were noted. Also, a sheet for participants, in which each of them assessed selected aspects of the project on a five-point scale. [Appendix H]

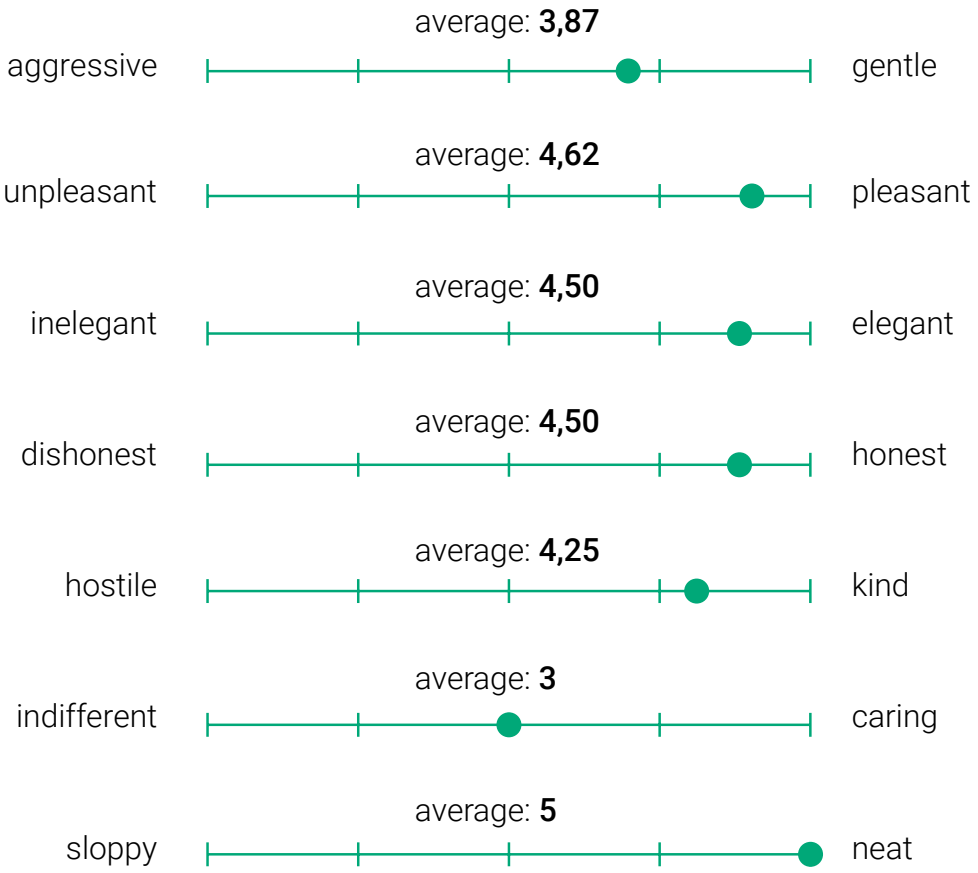
Besides, the context and application of the product were also explained:

„In front of you lies a wireless lamp designed for indoor and outdoor use, emphasizing outdoor use. The lamp's purpose is not to fully illuminate, but rather to provide additional or intimate illumination of the space in which you are located. The aim was to design a lamp that will allow you to arrange the mood and atmosphere of the surroundings around you, especially in a garden, on a terrace or a balcony. It is recommended to buy not one, but two or three lamps to achieve optimal flexibility and optimal space illumination possibilities. There is full freedom to use the lamp. It can stand horizontally, vertically, on the side, however you want, depending on your needs."

Appearance

The first step was to evaluate the appearance of the lamp. The product was placed on the table. Participants were asked what the product in front of them reminds them of. Often repeated answers were a saddle, a book, a house, or a roof, but the word ‘purse’ was the most frequent (6 times).

Then the participants were asked to imagine that the product in front of them is human and then rate the following characteristics on a five-point scale. Average results:



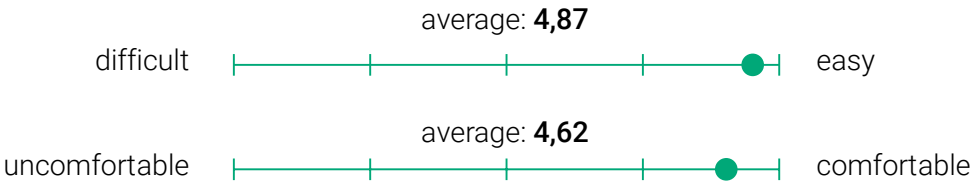
Convenience of carrying

The participants were asked to pick up the prototype and move the prototype from the table to the indicated place. Most often, they grabbed the lamp by the knob or by the sides of the lamp. They were asked to rate the comfort of carrying on a five-point scale. Result:

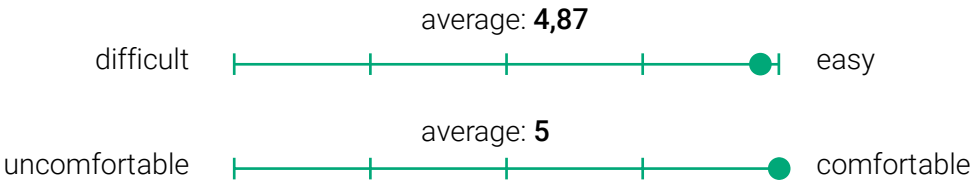
Operation / UX

One person in the couple was asked to go to another room, while the other, using only iconographic instructions, had to perform and evaluate each of the given aspects. After completing the task, it was time for the next person. Final results:

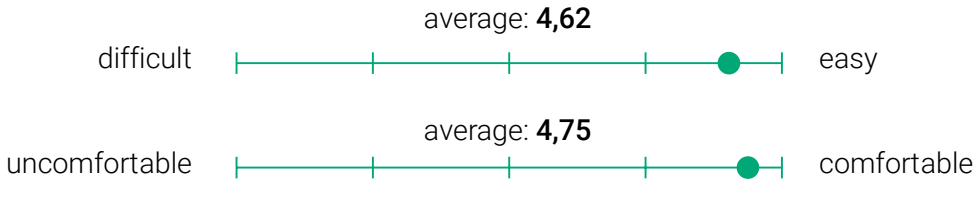
1. Turning light on/off



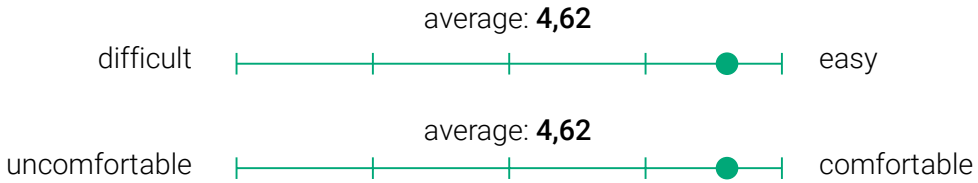
2. Controlling the light intensity



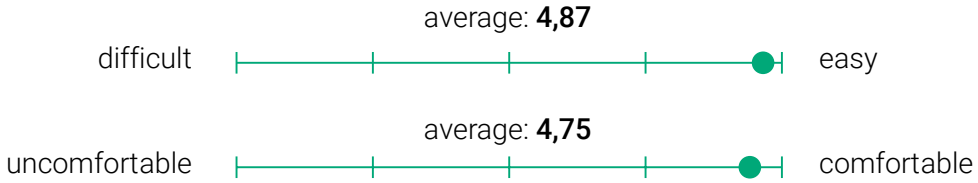
3. Controlling the light color temperature



4. Charging



5. Overall operation



Scenarios

The participants were asked to go outside - to the garden, on the terrace or the balcony, and then two scenarios were presented: a Romantic dinner and Apperitivo.

Romantic dinner

In the beginning, they were asked how they would arrange the space with only one lamp. Opinions were divided. Some users indicated that they would put the lamp on the table; others would place the product on the floor, illuminating an interesting detail or plants. The vast majority emphasized that in circumstances such as a romantic dinner, they prefer a dimmed warm light.

Figure 122: Romantic dinner light setting

They were then asked to imagine having more than one lamp and to indicate how they would arrange the space. Most indicated that they would place one lamp on the table and use the rest to illuminate the surroundings.

Figure 123: Surroundings illumination

Aperitivo

Respectively, the participants were asked for an informal dinner with more people. The participants would rather illuminate the surroundings than the table. However, unlike a romantic dinner, they would have opted for a slightly cooler light color.

Figure 124: Examples of Aperitivo settings

Home use

The participants were asked if they would use such a lamp at home. They unanimously indicated that it was. However, when asked about specific places, the same answers rarely

Figure 125: Examples of a home use settings

Figure 126: Examples of a home use settings

Light

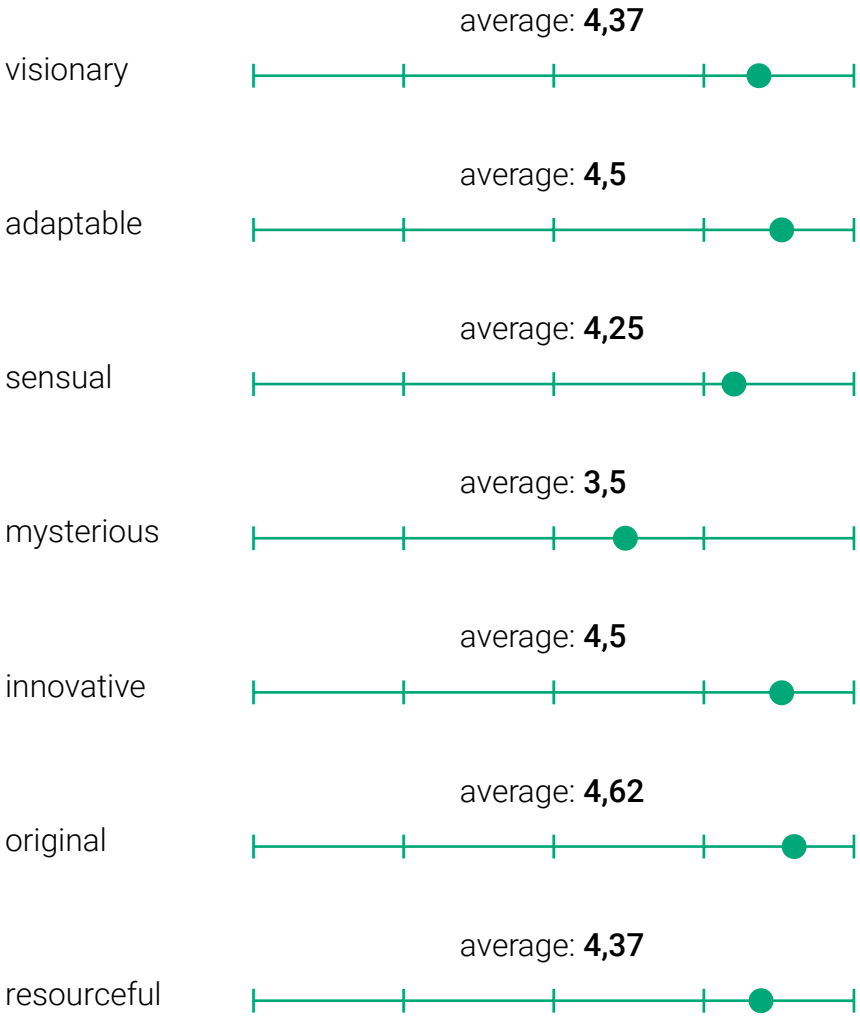
All participants indicated that they would use the possibility of changing the intensity of light and controlling the color temperature. They unanimously emphasized good light distribution. With one exception, when asked to characterize their partner's face in the light of a lamp placed horizontally on the table, they described it as attractive.

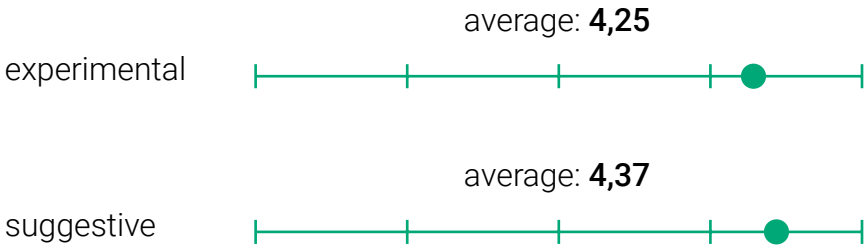
Half of the participants decided that the brightness range of the light was insufficient and could be a bit brighter. When asked about the color temperature range, 7 out of 8 participants found it sufficient.

Attendants suggested that a lamp placed upright on a table could strike some people. One participant suggested that it would be awesome if the transitions between brightness and color temperature levels were a little smoother.

Slamp Values

Finally, the Slamp values, which can be assessed from the prototype level, were presented. The participants were asked to confront and evaluate the product's reference to a given adjective from 1 to 5. Results:





Conclusion

It is worth recalling that the test was carried out on a prototype painted in navy blue gray LAR 7031 with a knob of the same color. This fact had an impact on the results, and it can be assumed that it would probably have been slightly different if the colors were more feminine, such as white or powder pink.

Overall, the lamp was positively received by the target group. Many of them involuntarily stated that such a lamp would be useful at home and would be happy to buy it.

Most importantly, for most of the participants, the lamp looks like a purse, which served as inspiration for its creation. Besides, the lamp performed very well in the appearance test. The product brings positive character traits and features to the mind. If it were a person, it would be a neat, pleasant, elegant, honest, and decent person.

Moreover, the interaction and operation of the lamp were very well assessed. Surprisingly, each of the elements, starting from turning the lamp on and off, changing the light intensity temperature, and charging, turned out to be very easy, intuitive, and comfortable for users.

Surprisingly, the participants found many uses for the lamp not only outside but also inside the home. They enthusiastically tested the lamp, discovering many applications in domestic use. When it comes to the scenarios, the users were more willing to arrange surroundings in the garden or on the terrace than the table itself. Depending on the occasion, they chose a diffe-

rent light temperature. Warmer during a romantic dinner, and cooler during aperitivo.

The participants liked the light distribution, and most of them said their partners looked favorable in the lamp's light. However, half claimed that the brightness range of the lamp is not sufficient and should be a little brighter.

The problem for users was the issue of carrying the lamp. Although they made it clear that the size and weight were ideal, it was not clear how to grab the lamp. Those who chose the knob suggested that it might be a little more comfortable to hold and feels unstable. Those who grabbed the outer casing said it was a bit too slippery. The most convenient grip turned out to be grasping the lamp by the ‚wings.'

It was interesting to see one of the participants who liked the rubberized texture of the knob. He emphasized that it significantly improves the grip and control over the properties of the light. Interestingly, the knob was not rubberized but painted with acrylic paint, which made such an impression. This is an interesting hint to the future that rubbing the knob may improve the operation and function of the knob.

Some participants missed the lamp charging status. Additionally, for two users, the charging feedback light was not visible. Participants suggested that with more lamps, it would be great if a smartphone application was also designed, from which you could remotely control everything at once.

Finally, based on the participants' grades, it can be concluded that the designed product fits very well with the values of the Slamp. The only value that scored slightly worse was ‚mysterious', scoring a 3.5 out of 5.

For all results, see Appendix F.

Conclusion

The project aimed to design an outdoor lighting system. The topic was so extensive that it gave a wide field for interpretation and many paths to take up the issue. A large part of the project was research in the field of outdoor lighting and all activities, to narrow down the topic.

The turning point was the interviews with users of private outdoor lighting systems. The vast majority of them emphasized that, despite permanent lighting systems, they use additional light sources to create mood and atmosphere during outdoor evening meetings. The thesis was a response to this need.

The result was the a wireless lamp designed for indoor and outdoor use. The lamp's purpose is not to fully illuminate, but rather to provide additional or intimate illumination of the surroundings and a space in which the users are located. The lamps allow them to tune the mood and atmosphere, especially in a garden, on a terrace or a balcony. It is recommended to buy not one, but two or three lamps to achieve optimal flexibility and optimal space illumination possibilities. Furthermore, there is full freedom of how to use the lamp. It can stand horizontally, vertically, on the side, however, users want, depending on their needs.

As the validation showed, the project was positively received by the target group. The function of the lamp is understandable. Interaction - adjusting the properties and functions of the lamp is hassle-free. The appearance of the lamp evokes positive associations. Importantly, light distribution was also assessed positively.

The only serious thing that requires additional consideration is to facilitate the handiness and the way of carrying the lamp.

Recommendations

Outer casing

The use of the two materials was simultaneously developed - PMMA and stainless steel. Ultimately, despite the advanced stage of work on bending and the use of PMMA, it was decided to use steel in the final prototype. The reason for this decision was the unsatisfactory gradient effect printed on PMMA modules. It is intended that the dark part of the gradient is 100% opaque while the lower part is transparent. Unfortunately, this effect was not achieved by printing, and as a result, with the lamp on, instead of a smooth transition between dark and light colors, you could see a sharp line of the inner casing. This problem can be solved by another method of producing a PMMA gradient. Instead of printing, it is possible to pour a PMMA sheet from two materials - transparent and opaque.

Improved grip

As validation showed, the grip must be improved. Perhaps carrying the lamp would be more convenient if PMMA was finally used. It is characterized by the lower weight and, above all, a matte texture, less slippery than powder-coated steel. During validation, it was noted that many users are willing to carry the lamp by the knob. However, this is not convenient enough. Further work on the ergonomics of the knob is advisable.

Diffusor

Although individual LEDs are not visible on a semi-matt or semi-gloss surface, it is recommended that the light be even more diffused. Individual LEDs do not look very aesthetic. It was also pointed out during validation. This effect can be improved by using a different type of diffuser, increasing its thickness, or even the distance between the diffuser and the LED strip.

Charging feedback

Charging feedback is not good enough. During the study, users suggested the use of external LEDs suggesting the lamp's charge level. Furthermore, the currently used LED is invisible when connecting the power cable with the light on. A better application could be a short animation, blinking all LEDs, or a moment of color change, suggesting that charging is in progress.

Sealing

For additional protection and to ensure that the electrical system remains tight, it is recommended to increase the number of screws fixing the diffuser to the inner housing to six. The extra two should be placed between the current four.

More sizes

During the validation, although all participants agreed that the size and weight were ideal for the chosen application, some people suggested that it would be great if the lamp could be available in several sizes.

App

The study participants emphasized that if they have more lamps, it would be convenient to use a smartphone control application. Thanks to the App, it would be possible to control the arranged scene/atmosphere/mood more easily.

Acknowledgments

I would like to thank my supervisors, Prof. dr. Sylvia Pont and Ir. Stefan van de Geer for all the tips, remarks you gave me during the project, sometimes for taking my hand and constructive criticism, which is an indispensable part of a good design process. I am glad that despite the difficulties caused by the coronavirus, we have managed to build a thread of understanding and efficient remote communication.

I would like to thank Katerina Karagkouni for cooperation, all tips, and comments about the project. For being an intermediary between me and my vision and the vision and values of the Slamp. Besides, for sent components and cooperation with prototyping. I would also like to thank Luca Mazza, the art director, and all the Slamp employees who contributed to my project's development and whom I didn't get to know.

A special thanks to Wiktor Mucha for the invaluable help in programming the lamp's interaction and function. Without you, this lamp wouldn't work.

Thanks to Michał Filatiew, for dozens of cut steel elements and a necessary contribution to expanding my knowledge about metals and their properties.

I would like to thank Bartek Kędziora for the evenings spent photographing the final prototype.

I would like to thank Marek Torbus, Deniz Söğütlü, and Jan van Ackeren for their valuable advices throughout the design process. Your advice has often turned out to be groundbreaking and had a decisive influence on the final result.

I would also like to thank my family and my girlfriend for their support and a lot of accurate and valuable comments.

Finally, I would like to thank the people who took part in the interviews, and the product validation and all the others who were not mentioned by name contributed to the final result of the project.

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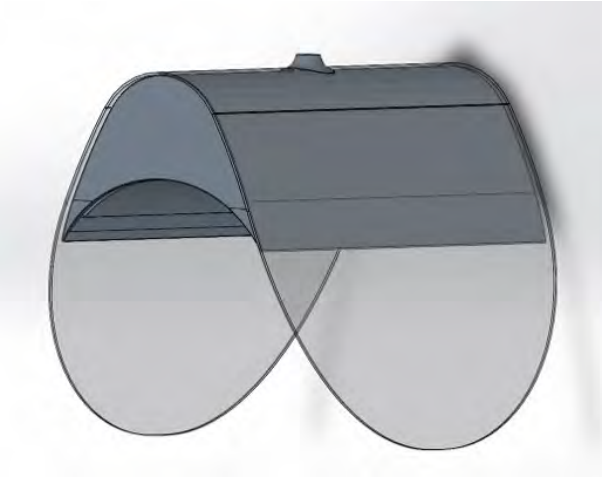
Appendices

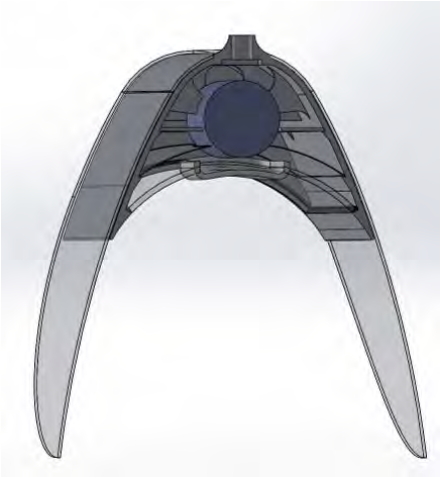
Appendix A

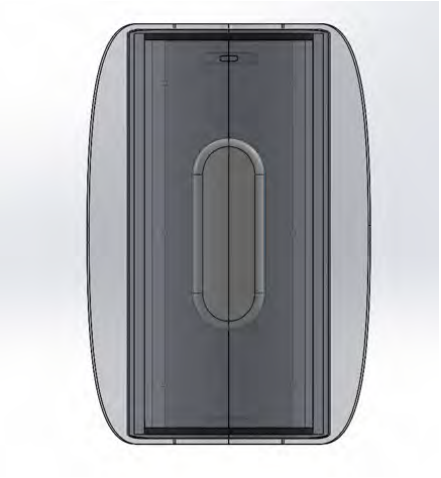
Name:	Irena	Gabi	Zuza	Magda	Kuba	Michal	Dorota	Jurek	Bartek	Marcin	Michal B	Andrzej
Age:	65	72	28	30	25	25	55	72	44	25	44	55
Do you have Garden/ Terrace/ Balcony?	Garden, Terrace	Garden, Terrace	Garden, Terrace, Balcony	Balcony	Terrace	Garden, Terrace	Terrace	Terrace, Garden	Terrace, Garden	Garden, Terrace, Balcony	Garden, Terrace	Garden/Terrace/ Balcony
Do you use outdoor lighting?	YES	YES	YES	YES	Not often	YES	YES	YES	YES	YES	YES	YES
If yes, what kind of outdoor lighting do you use?	wall lamps, bollard lights, pendant lamps, step lights	wall lamps, step lights, bollard lights, garage halogen	ceiling lamps, pendant lamps, spotlights, halogens front	ceiling lamp	wall lamp	wall lamps, bollard lamps, pendant lamps,	wireless wall LED light, normal wall lamps	Solar floor lamps, halogens, garden lamps posts	pendant lamps, wall lamps	wall lams, bollard lamps, step lights	wall lamps, spot lights	bollard lamps, pendant lamps,
Why do you use this kind of lighting? What do you want to achieve by using these lamps?	I want to illuminate my garden and create nice atmosphere	I want to illuminate my garden and create nice atmosphere, against the bulglar, when someone is coming, party	I want to accentuate interesting plants, elements of the garden, identifying bulglars	Illuminate balcony, Function purpose	I don't use it very often because I have huge window and it's bright enough on terrace, also my otidoor light is very weak, I use it when I want to water the flowers	illuminate the garden, decorative purpose,	path illuminating, safety - bulglar	illuminating the sculptures, accentuting important parts of the garden, paths	to achieve nice atmosphere and illuminate the garden	functional - illuminating the garden and decorative	illuminating and for nice looking	nice looking and illuminating- functional, accentuate nature
If you have lighting system, did you assemble it yourself?	designer designed the lighting sytem, the mounter mounted the lights	designer designed the lighting sytem, the mounter mounted the lights	electrician, the lighting system was designed by professionals	electrician	electrician	electrician	some electricians, some themselves	alone	electrician and myself	some ourselves, some electrician, designed by proffesionals	electrician	electrician
Is something irritating in your outdoor lighting system? Would you like to change something?	The lamps on the wall got rusted, **step lights are annoying because shine streight into the eyes**	lights over the garage	the lighting system can be controlled only by the app, ther are no physicall buttons, lights are too bright to make a nice atmosphere, when you turn it off it's to dark, a lot of issues with step lights	weak light	Light is unpleasant	we use garden lights only during the summer, after the winter always something is broken and we need to fix it, **after some time we spotted that this lighting setup is not perfect and we would change something but it's hard because everything is fixed**	angle of the light, we can't ajust it, too little freedom	-	-	it looks different than in the poject, **if you want to add the light it's hard to find excatly same color**	-	-
Now imagine, there are warm summer evenings, your friends/ family are coming and you want to spend night hours with them outside.												
Where do you spend this evening?	I have a big terrace, so I have two places to spend time there	Terrace	Terrace mainly	only balcony	terrace	terrace	terrace	few places in the garden, terrace	terrace	terrace	terrace	terrace
Is it place where you do it always or you change the locations?	terrace front or the side	larg terrace, i can move from one place to another if I want	sometimes I chabe location and go on the lawn to play some party games with friends	-	I go to the plecaes where i have easy access to the socket	sometimes we go to the garden	-	we change	**mainly terrace becuse rest of the garden is dark**	sometimes bower	no	sometimes bower
Do you use some additional (not fixed) lighting to illuminate the place where you seat?	pendant LED solar lamps, lanterns	candles, celling lamps	I use candles mainly	wirless LED chain	I use garlands	candles, when it;s more people we use halogens	candles, kerosene lamp	candles, lanterns, chinese lanterns, garlands	our terrace is bright but we use candles	gerlands, candles	candles, solar 'chinese' lamps	candles
Why do you use this thing, specifically?	**Wall lamps are weak**	**candles to create a nice atmosphere, when guests are coming**	for atmosphere and gettig rid of mosqitos	atmosphere	they have nice lights	candles - atmosphere	nice atmosphere, intimacy, illuminating places which aren't bright enough	symblic purpose, paths, atmosphere	for atmosphere	for nice atmosphere	nice discreet light	atmosphere
Is there something that is extremely annoying when using this product?	LED solar lights are too weak	-	smell	light isn't bright enough	-	steady light, no control, sometimes is to bright	-	-	when you leave candles outside they are getting useless especialy when it's raining	**cables are annoying**	**I wish they are more durable and illuminating longer**	-
Would you change something in this product?	-	-	-	Light is cold, I prefere warm light	-	more control	-	-	-	-	-	-

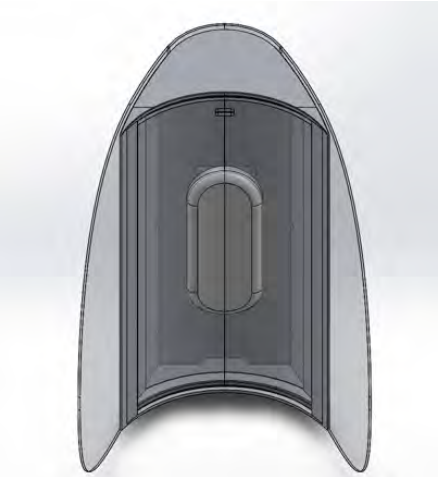
Appendix B

1st version of inner casing





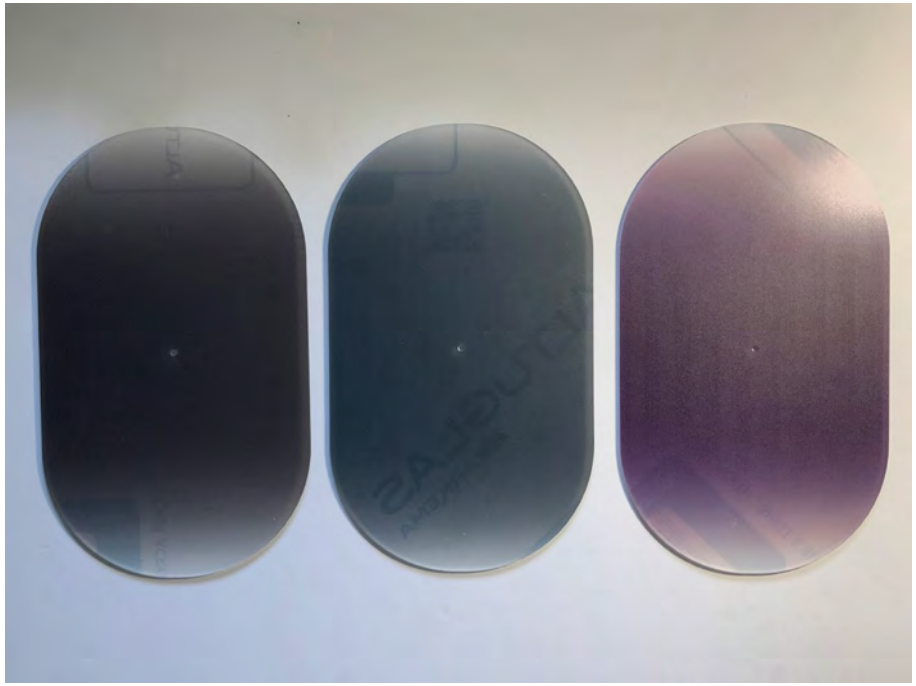


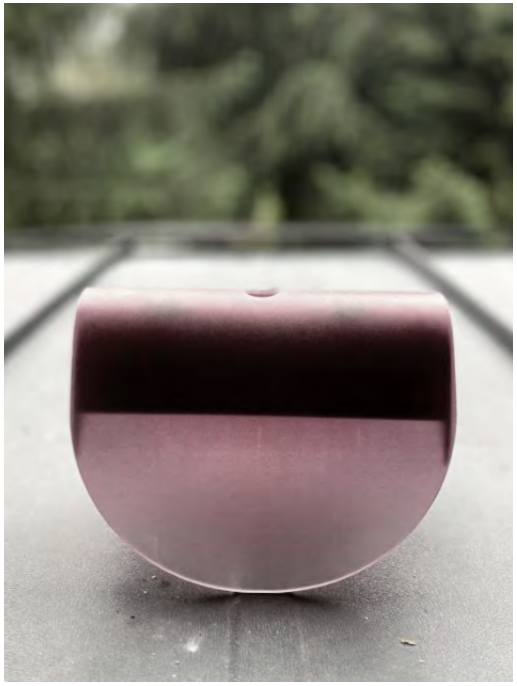


The first version of the inner casing was characterized by significantly larger dimensions than the final version. Along with a different housing design, the use of a diffuser also differed. Had to be bent. In the final version, the positioning elements of the battery, space for the encoder, and cables were also improved. The factor that determined the complete change of design was the unsightly appearance of the edges of the inner casing at certain angles.

Appendix C

In cooperation with Slamp, the external housing modules were made of PMMA. The modules have previously designed multi-color gradients. Unfortunately, the final effect was a disappointment because the product did not meet its expectations. The gradient's dark side was not opaque enough, so the internal casing was visible under the influence of the light.

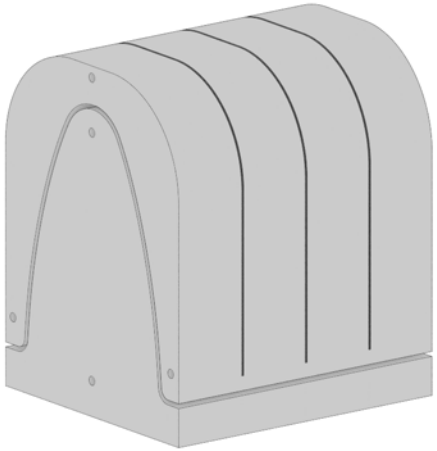


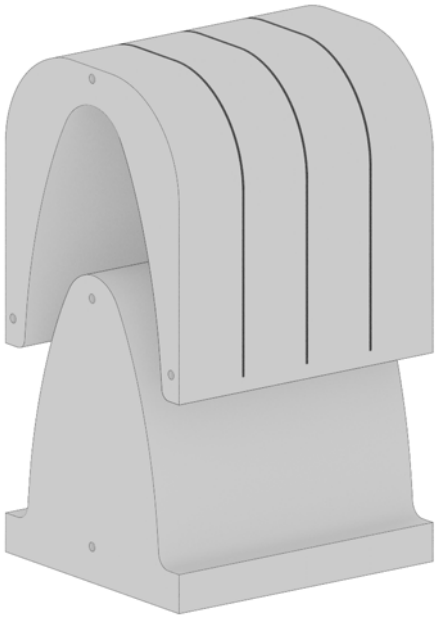


Appendix D

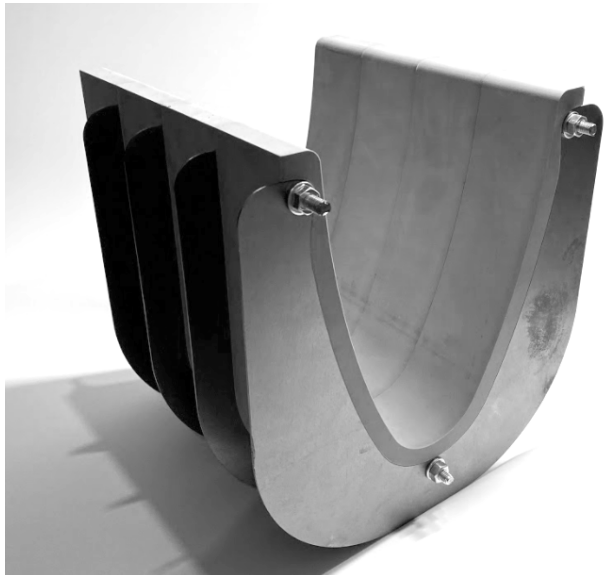
The special mold has been designed for bending PMMA modules intended for the outer casing. For the construction ProLab material was used, which, due to its high density, is used in applications where high accuracy is required. Due to the 5 cm thickness of the material sheet, the mold had to be divided into four parts and later connected. 1mm low carbon steel arches were used to strengthen the structure.

Parts from ProLab have been milled, while steel arches have been laser cut.





In order to increase the strength, in the final version, the metal arches were enlarged. All elements were connected with 6 mm threaded rods.

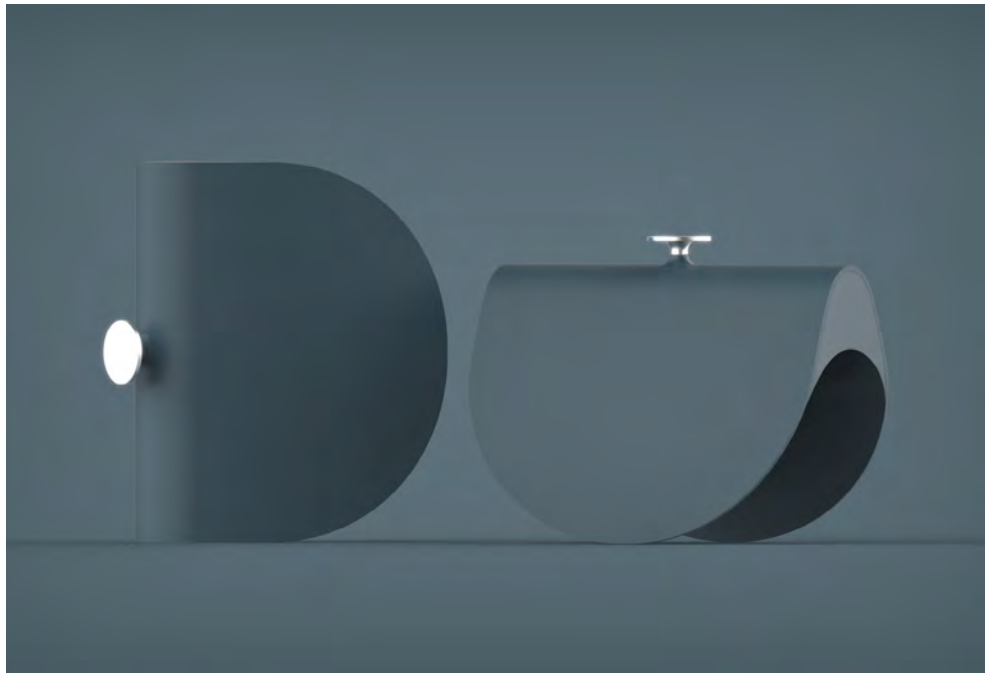


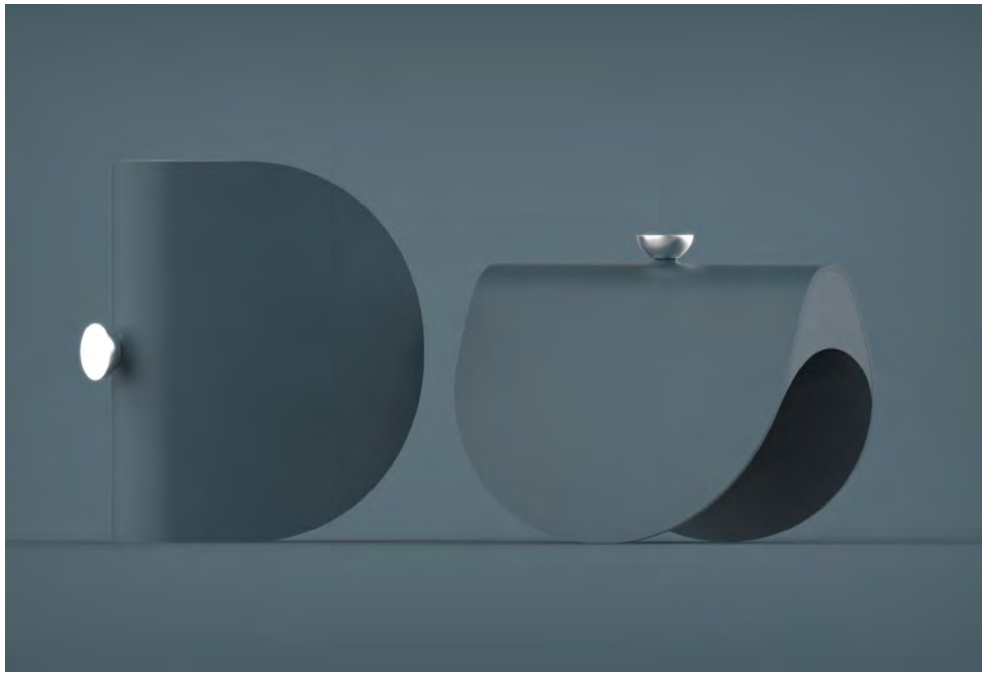
For bending, the PMMA modules are heated to 160 °C. The heated sheet is placed on the lower part of the mold and pressed with the upper part. The module remains compressed until it cools down.

Appendix E

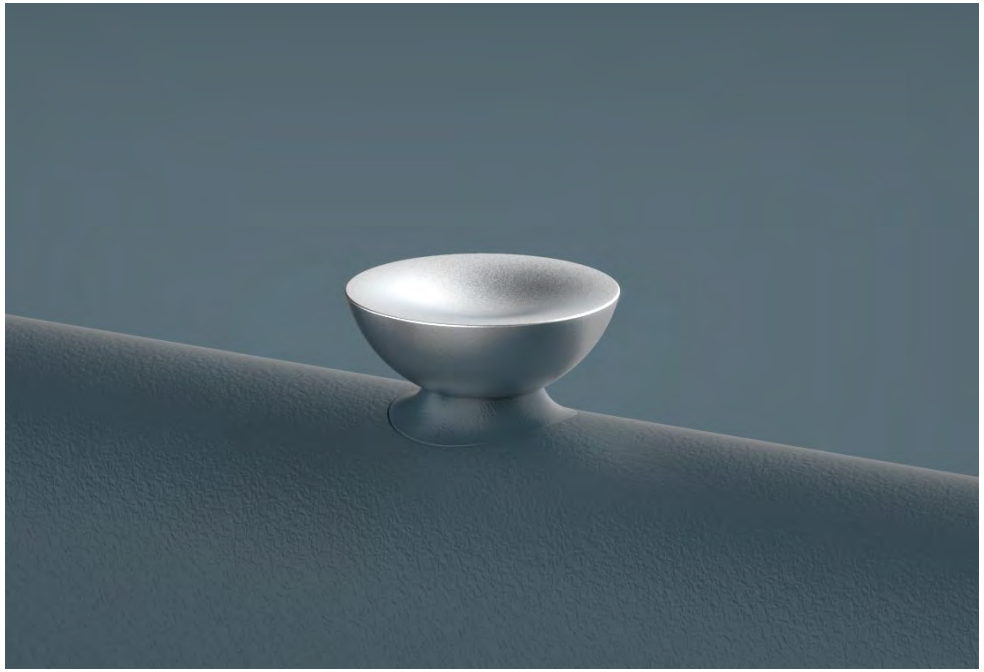
An ideation was carried out in order to find a knob that will fit better with the shape of the lamp than the previous sphere. In addition to the visual aspects, the knob obviously had to allow for comfortable control of the light properties. The following visions were created:

Two concepts were selected for further development. The first one, openwork, was to facilitate carrying the lamp. The second one refers to the form of a lamp.





In both designs, a slight dent imitating the touch of a finger has been added to indicate the possibility of pressing the knob. Finally, it was decided to choose a second, more solid in appearance knob. It was found that its volume more closely matches the design of entire lamp.



Appendix F

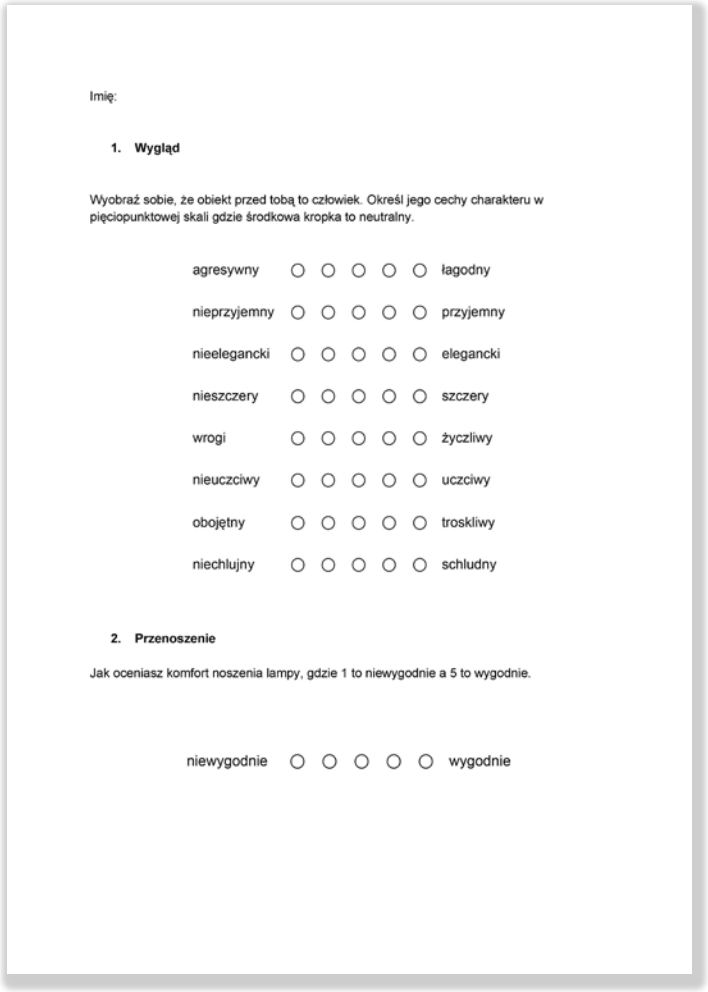
Name	Grzesiek	Maja P.	Michał	Ania	Bartek	Maja	Jacek	Magda	Average
Age	40	40	45	45	45	42	46	41	
Status	Married, 2 kids	Married, 2 kids	Married, 3 kids	Married, 3 kids	Married, 1 kid	Married, 1 kid	Married, 2 kids	Married, 2 kids	
1. Appearance									
What does the shape resemble to you?	saddle, mold, open book, rocking horse	saddle, knob - sunction cup, purse	house, closed omelette, nails lamp	house, purse	house with a chimney, purse	hip-flask, purse	saddle, purse	purse, open book	
aggresive - gentle	5	5	3	3	3	4	4	4	3,875
unpleasant - pleasant	4	5	5	5	4	4	5	5	4,625
inelegant - elegant	3	5	5	5	4	5	5	4	4,5
dishonest - honest	5	5	5	4	5	5	4	3	4,5
hostile - kind	5	5	5	5	3	3	4	4	4,25
dishonorable - decent	5	4	5	4	5	4	4	4	4,375
indifferent - caring	3	3	3	3	1	4	2	5	3
sloppy - neat	5	5	5	5	5	5	5	5	5
2. Convenience of carrying									
How would you carry the lamp?	most preferably knob, but it's not super comofortable	knob	knob	sides of the lamp (arms)	firsty knob but then spotted it's not secure so sides	knob or the sides	i don't want to grip for LEDs, if you carry by the top is slipper, knob is insecure	to wide to grip from be top, the knob	
How comfortable is that? 1 uncomfortable - comfortable 5	2	2	3	3	4	5	3	3	3,125
What do you think about the size and weight of the lamp?	metal makes it look solid, plastoc is shitty, size is optimal, i wouldn't like it bigger, i like the rubber knob, it's not very handy	it's quite light but it still has some weight which is nice, it makes impression of solid	size is perfect, same as weight	size is perfect, same as weight	it's ok, not too heavy, not too light	it's ok	size is perfect, weight is optimal, it's good fot a wind, not to heavy.	good for bigger table, for small garden table might be a bit too big	
3. Operation / UX									
Turning the light on/off									
Comments.									
difficult - easy	5	5	5	5	5	5	4	5	4,875
uncomfortable - comfortable	5	3	5	5	5	5	4	5	4,625
Regulating the light intensity									
Comments.									
difficult - easy	5	5	5	5	5	5	4	5	4,875
uncomfortable - comfortable	5	5	5	5	5	5	5	5	5
Regulating the light color temperature									

Comments:					would be nice if transtions are smoother				
difficult - easy	5	5	5	5	5	5	3	4	4,625
uncomfortable - comfortable	5	5	5	5	5	5	3	5	4,75
Charging the lamp									
Comments:	would be nice to have a charging status, when it's turn on and you want to connect the plug, the light snikes, charging status outside, status ring on the chimney				better feedback, it's nice that is USB -C, it's more convenient than other ones	you can't see the feedback diod when the light is turn on			
difficult - easy	5	3	5	5	5	5	4	5	4,625
uncomfortable - comfortable	5	3	5	5	5	5	4	5	4,625
Overall interaction									
Comments:									
difficult - easy	5	5	5	5	5	5	4	5	4,875
uncomfortable - comfortable	5	5	5	5	5	4	4	5	4,75
Overall easiness									
Overall comfort									
4. Scenarios									
Imagine that you have a romantic dinner outside.									
How and where would you use the light?	floor, table ok but prefer floor, lighting the surrounding	i would illuminate something pretty, flower, plant wall, sculpture	if i have one lamp i would illuminate something nice like plant, not table	if i have one lamp - table - central place of the dinner, if more - table and surroundings	on the table, it's coole because you can make an atmosphere very nice, maybe it doesn't fit excatly to elegant dinner, more to spontanious chilling with wife, if i have more i would illuminate surroundings, even further away garden, trees, pants ,etc	surroundings, I still prefer candles on the table	if one - the table, if more the table and surroundings	one lamp - table, if i have more - one table others around	
Please find a suitable lighting setting for you.	warm setting	dimmed warm light	warm light	warm light	warm table, cool surroundings	warm light	warm light	warm	
Imagine that you have dinner or spend time with a larger number of people									

How and where would you use the light?	not the best for the table, for one it's good but for another strikes into eyes,	used as a additional light, not for eating, eventually horizontally	various places	around	around	one on the table, others around	the same, you need to have more lights for the dinner with more people	surroundings	
Please find a suitable lighting setting for you.	eventualy dimmed on the table		cooler light, more energetic	cooler light	cooler light	warm on the table, cool around		depends	
Would you use it at home?									
If yes, where? Where would you place it?	everywhere, it's mobile, doesn't have a cable	walls, furnitures, kitchen because i have weak light there,	taking bath	next to the bad, side lamp before sleeping	meditation	reading, sleeping, calming down, staires	i would use it mainly in garden beacuse i have a lot of light inside	relax, as a candle, a allow a bit better exposure	
Please find a suitable setting for you.	depends	depends	depends	depends	depends	depends		warm	
5. Light									
Would you change the light setting depending on the scenario?	yes	yes	yes	yes	yes	yes	yes	yes	
How do you like the light distribution and how it lights surfaces?	it's good	it has very good opening angle, horizontally and vertically, it's perfect, even when it's on the side	yes, in my opinion the lamp is even nice to small work, like writing something or working on the laptop	it's good	I like it, it's very romantic light, good looking glasses	yes	yes, the shape is interesting	yes and it's nice taht it changes depends on position	
Can you describe your face impression? Healthy, tanned, shiny, scary etc	it's quite normal	when the lamp is horizontally on the table,faces are a bit different, a bit uglier, but not to much	attractive because you don't see wrinkles	attractive and misterious	he looks good, atractive, fresh	attractive	looks good	ok	
Is the brightness range sufficient?	a bit less and a bit more	a bit less and a bit more	a bit brighter	brighter	it's enough	sufficient	sufficient	ok	
Is the temperature range sufficient?	Yes, it's good, would be nice to have a fluent transition	it's ok	it's good	enough	a bit warmer	it's good	sufficient	sufficient	
What do you dislike about the light?	strikes sometimes, you can see diods but i can get use to that	sometimes strikes	would be nice to have a light a bit bigginter	we want it a bit brighter	fluent transitions	-	-	-	
6. Final									

What would you change/improve?	maybe colors, would be perfect to have the App to control more lamps	-	it would be nice to have more sizes	we would buy it, more sizes	rigid grip, more certain feeling of holding,different color knob, it see the lamp as to create atmosphere less for eating	it would be nice if the knob is the same material as lamp	the loght more spread, better grip	grip	
5. Slamp Values									
visionary	4	4	5	5	4	4	5	4	4,375
adaptable	5	5	5	4	4	5	5	3	4,5
sensual	4	4	4	5	4	5	4	4	4,25
mysterious	3	5	5	3	3	2	4	3	3,5
innovative	4	5	5	5	5	4	4	4	4,5
original	5	4	5	5	5	5	4	4	4,625
resourceful	5	4	5	5	4	4	4	4	4,375
experimental	3	5	5	5	4	4	4	4	4,25
suggestive	5	4	5	5	3	4	4	5	4,375

Appendix H



Imię:

1. **Wygląd**

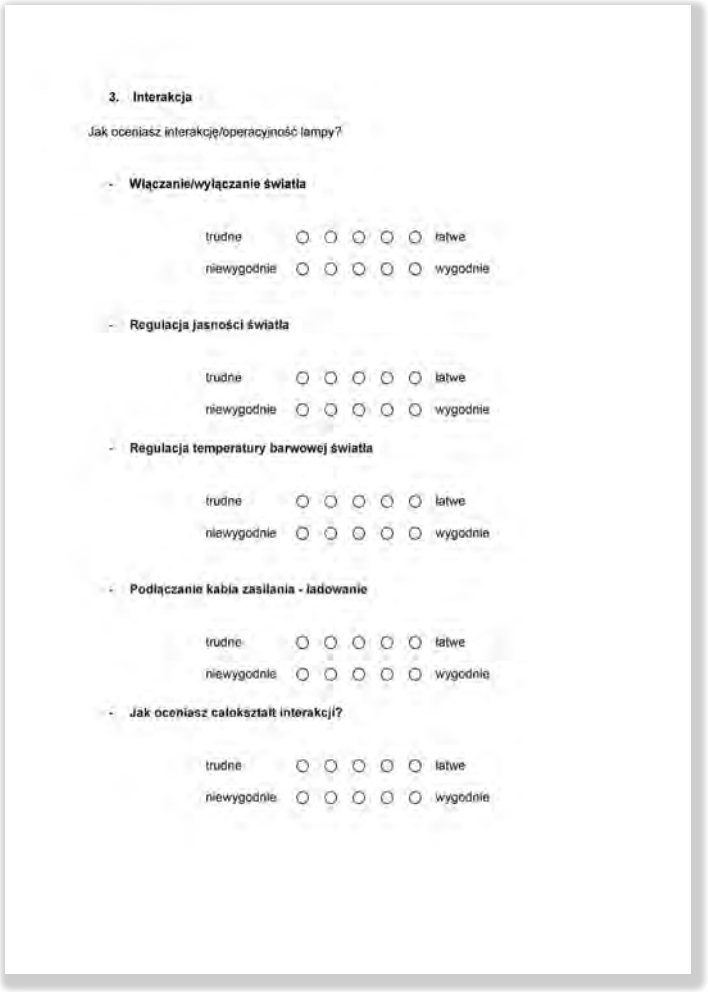
Wyobraź sobie, że obiekt przed tobą to człowiek. Określ jego cechy charakteru w pięciopunktowej skali gdzie środkowa kropka to neutralny.

agresywny	○	○	○	○	○	łagodny
nieprzyjemny	○	○	○	○	○	przyjemny
nieelegancki	○	○	○	○	○	elegancki
nieszczery	○	○	○	○	○	szczery
wrogi	○	○	○	○	○	życzliwy
nieuczciwy	○	○	○	○	○	uczciwy
obojętny	○	○	○	○	○	troskliwy
niechlujny	○	○	○	○	○	schludny

2. **Przenoszenie**

Jak oceniasz komfort noszenia lampy, gdzie 1 to niewygodnie a 5 to wygodnie.

niewygodnie	○	○	○	○	○	wygodnie



3. **Interakcja**

Jak oceniasz interakcję/operacyjność lampy?

- **Włączanie/wyłączanie światła**

trudne	○	○	○	○	○	łatwe
niewygodnie	○	○	○	○	○	wygodnie

- **Regulacja jasności światła**

trudne	○	○	○	○	○	łatwe
niewygodnie	○	○	○	○	○	wygodnie

- **Regulacja temperatury barwowej światła**

trudne	○	○	○	○	○	łatwe
niewygodnie	○	○	○	○	○	wygodnie

- **Podłączanie kabla zasilania - ładowanie**

trudne	○	○	○	○	○	łatwe
niewygodnie	○	○	○	○	○	wygodnie

- **Jak oceniasz całokształt interakcji?**

trudne	○	○	○	○	○	łatwe
niewygodnie	○	○	○	○	○	wygodnie

Name: Age:

Lamp - **Qualitative Research**

Target group: **40-50 y/o, middle income, access to garden, terrace, balcony**

Method: **In home visit, combination of observation and interview**

1. **Appearance:**

- What does the shape **resemble to you?**

- What do you think about chosen materials?

- Human characteristics: **Please fill the brochure.** [FILL]

2. **Convenience of use:**

- How would you **carry the lamp?** How comfortable is that? [FILL]

- Is the **size and weight ok?**

3. **Operation:**

- Can you turn the **light on/off?** [FILL]

- Can you set a lower **light intensity?** How easy is it? [FILL]

- Can you set a warmer **light temperature?** Now higher. How easy is it? [FILL]

- How convenient is **overall interaction?** [FILL]

- Are you able to charge the lamp? How easy is it? [FILL]

4. **Scenarios:**

- Imagine that you have a **romantic dinner outside.** How and where would you use the light? What would be the light setting? **Please find a suitable lighting setting for you.**

- Imagine that you **have dinner or spend time with a larger number of people?** How and where would you use the light? What would be the light setting? **Please find a suitable lighting setting for you.**

- Would you **use it at home?** If yes, where? Where would you place it? **Please find a suitable setting for you.**

5. Light

- Would you change the light setting depending on the scenario?
- How do you like the light distribution and how it lights surfaces?
- Can you describe your face impression? Healthy, tanned, shiny, scary etc.
- Is the brightness range sufficient?
- Is the color temperature range sufficient?
- What do you dislike about the light?

6. Final

- What would you change/improve?