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Makeup Artist Hand Sanitizer

Final Report

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Abstract

This project outlines a project focused on creating a prototype to clean and dry covered makeup hands. The project stemmed from extensive discussions with the customer, resulting in the central aim: "Develop a prototype for cleaning and drying dirty makeup hands."

The project's objectives were systematically structured to achieve this goal. The initial phase entailed a thorough exploration of the customer's needs to establish requirements for the hand sanitiser machine within a two-week timeframe. Collaboratively, a set of requirements was established to ensure alignment between the customer and the project team.

The subsequent design phase, scheduled for completion before midterms on October 30th, involved generating drafts and technical drawings based on the agreed-upon requirements.

Upon successful conclusion of the design phase, the project proceeded to its final milestone: launching a fully functional prototype based on the established design by the project's end. This marked the successful accomplishment of the project's overarching aim.

The project employed a customer-centric approach, incorporating needs assessment, requirement definition, and design to meet the customer's demands. Materials that are utilised include technical drawings, design documents, and various components for the prototype.

Language: English
Key Words: Makeup, Hand Sanitizer, Design, Prototype, Testing

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1 Introduction

Within this chapter, the aim is to provide a comprehensive guide tailored specifically for navigating the intricate dynamics of project collaboration and cultural nuances within the EPS program in Finland. The exploration begins with the Project Background, offering a general understanding of the contextual framework essential to collaborative endeavours. The dynamics of The Team are pivotal to the discussion, shedding light on the influences of diverse cultures on the synergy and outcomes of joint efforts. Additionally, Effective Group Communication, a cornerstone, will be explored, illuminating the diverse communication styles across cultures and their profound impact on collaborative initiatives. Furthermore, the Sanitizing of Hands will be stated, unveiling its history and use, thus providing invaluable insights into the cleaning of hands. This comprehensive exploration endeavours to equip readers with indispensable knowledge crucial for successfully reading this report.

1.1 Project Background

When applying makeup, there is a high chance that makeup residue will remain on the hands afterwards. For those who regularly do makeup, it can be quite inconvenient to keep going to the bathroom to clean the hands. This back-and-forth can be time-consuming and disrupt the makeup application process. This is where the idea for a Makeup Artist Hand Sanitizer, conceived by Christina and Isabel Bjon, comes into play.

The central idea behind the Makeup Artist Hand Sanitizer is to offer a solution that not only removes makeup residue from the hands but also dries afterwards. To achieve this, the device incorporates two key features: bristles for scrubbing and a water distribution system. However, it is important to note that water alone is not enough for thorough hand cleaning, so the device allows for the addition of soap or makeup remover. This combination ensures that makeup residues are effectively removed, leaving the hands moist.

After the cleaning process, the hands need to be dried, and there are different methods to consider for achieving this. This aspect of the product requires further refinement to determine the best way to clean and dry the hands effectively.

Creating the Makeup Artist Hand Sanitizer involves a thorough design process, starting from scratch. To make it fit seamlessly into a makeup environment, the product should be compact and aesthetically pleasing, blending well with the makeup table.

To bring this innovative concept to life, various factors need to be carefully considered, including material selection, ergonomic design, the power source for drying mechanisms, ease of maintenance, user interface design, safety features and adherence to regulations.

The development of the Makeup Artist Hand Sanitizer holds promise for simplifying and improving the makeup application process. Conducting in-depth research, meticulous design work, rigorous testing, and effective marketing will be essential steps to realise this concept's potential in meeting the needs of makeup enthusiasts.

2 The Team

Within this segment, "The Team," lies a crucial aspect influencing our collective pursuit within the EPS program in Finland. This section offers a perspective into the team's structure, outlining the introduction and contributions of each member. Furthermore, it delves into the analysis of Belbin Roles, a framework utilized to comprehend individual strengths and roles within the team. By examining the Belbin test results conducted with each member, the aim is to provide an overview of the initial team configuration and how the roles and dynamics have evolved. This exploration serves to illuminate the diverse strengths, attributes, and dynamic shifts within the team, essential for fostering effective collaboration and achieving collective goals within the EPS program.

2.1.1 Team Members

Guyon De Abreu

The first member is Guyon De Abreu (Figure 1). Guyon is currently pursuing his studies at Avans University of Applied Sciences in ‘s-Hertogenbosch the Netherlands. With an academic background associated with Industrial Engineering, Guyon already had experience with project management. His interests include fitness, socializing and exploring new things. During the project, his role involves planning, coordinating and mapping financials.

Figure 1. Guyon De Abreu. (own author).

Santiago Sanz

Figure 2. Santiago Sanz. (own author).

The second member is Santiago Sanz (Figure 2), a last-year student of industrial design engineering in the region of Catalonia, Spain. Santiago has experience working on projects for his university, playing the role of a design engineer and developing products from scratch, so this member is familiar with the product design process as a whole. His hobbies are 3D printing, field hockey and Formula 1.

Sabine Welmerink

Figure 3. Sabine Welmerink. (own author).

The third member of this group is Sabine Welmerink (Figure 3). Sabine currently studies at Saxion University of Applied Sciences in Enschede, the Netherlands. With a background in Mechatronics, which will be a combination of Electronical, Mechanical and Software Engineering, technically, this will be a good addition to the team. Sabine's interests are baking, socializing, bouldering and improving.

2.1.2 Belbin Roles

Dr Meredith Belbin defines a 'Team Role' as one of nine specific clusters of behavioural attributes that his research at Henley has identified as effective for enhancing team progress. Belbin notes that while people can engage in a wide array of behaviours, there is a finite range of behaviours that significantly contribute to team performance. These behaviours are categorized into distinct clusters, collectively referred to as 'Team Roles.' The roles are shown in Figure 4.

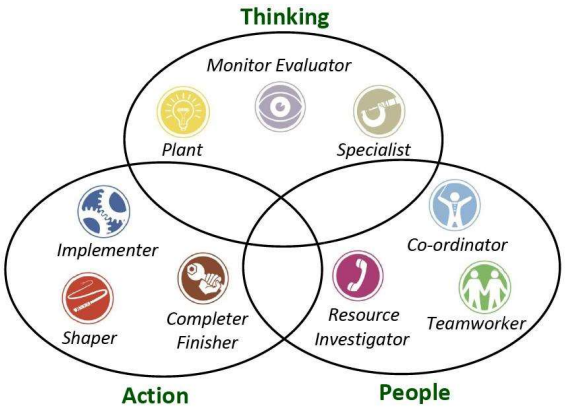


Figure 4. Belbin Roles. (ObjectGears, n.d.).

Meredith Belbin's research highlights the importance of assembling teams with a diverse blend of behaviours. To create high-performing teams, it is essential to incorporate representatives of each of the nine Belbin Team Role behaviours at appropriate junctures (Belbin, n.d.). In Appendix 1 every role is defined, along with the strengths and weaknesses. Also, the results of the Belbin tests from each team member are specified in Appendix 1 as well as an individual opinion of the results.

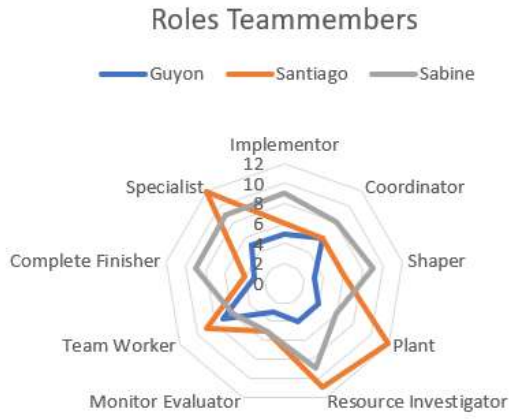


Figure 5. Belbin Roles Radar. (own author).

In the team there are multiple noteworthy roles in which each member is exceptional, see Figure 5. Guyon's characteristics are soft, however, this member stands out as a Team Worker and a Coordinator. The strengths of a Team Worker and Coordinator are e.g., confident decision-making and diplomacy to avoid friction in the project group. The weaknesses of these characteristics are being manipulative and making unpopular decisions (Belbin, n.d.).

Santiago's Belbin test results indicate that this member leans towards being a 'Specialist,' which means Santiago enjoys diving deep into specific areas of expertise. This helps this specialist contribute effectively to his team. His test results also suggest Santiago has a touch of 'Plant' in him, showing he is open to creative and innovative thinking. Sometimes, Santiago produces fresh ideas to support his team's projects. Moreover, Santiago excels at being a 'Resource Investigator.' This member should be good at making connections, finding opportunities, and getting the necessary information and support for his team (Belbin, n.d.). Santiago agrees with these characteristics.

Last but not least, Sabine has various roles according to the Belbin test. The most remarkable results were Implementer, Shaper, and Complete Finisher. Carrying the role of implementer means that this member plans a workable strategy. Also as Shaper, Sabine provides the necessary drive to ensure that the team keeps moving. Lastly, as a Finisher, the member tends to be most efficient at the end of tasks. The strengths of these roles are working efficiently, overcoming obstacles, and searching out errors. The weaknesses are being inflexible, offending people's feelings, and being too perfectionistic (Belbin, n.d.).

All these roles together cover most of the nine Belbin roles. However, Monitor Elevator is a critical role that no team member is affiliated with. This role contains aspects like a logical eye in the team, which can contribute to making impartial judgements when it is necessary. Strengths that the group will lack are soberness, mapping all possible options, and judging accordingly.

2.2 Group Communication

Within the Group Communication domain, critical facets profoundly influence collaborative dynamics within the EPS program in Finland. This segment embarks on an exploration of two pivotal models: the Trompenaars model and the Hofstede Cultural Insights model. These frameworks serve as guiding pillars, exposing diverse cultural dimensions that impact communication styles and interactions within our collaborative environment. By scrutinizing these models, we aim to unveil intricate cultural nuances, fostering a deeper comprehension of communication dynamics across diverse cultural backgrounds. This comprehensive analysis seeks to provide invaluable insights essential for navigating and optimizing communication strategies within our collaborative framework.

2.2.1 Trompenaars Model

There are competing measures of intercultural communication. One such measure is Trompenaars's Cultural Differences (THT Consulting, n.d.). This has found favourable use over Hofstede for the differences between the Dutch and Spanish cultures.

The results of the cultural differences from Trompenaars's model can be found in Figure 6. It is determined to use the Dutch and Spanish cultures because these are the nationalities in the project group.

Figure 6: Trompenaars's cultural differences. (THT Consulting, n.d.).

Universalism/Particularism

This dimension highlights how some cultures prioritize strict adherence to universal rules, while others prioritize relationships and exceptions. The Dutch tend to lean toward universalism, emphasizing rule-based approaches, in contrast to the average Spanish preference for particularism, which values relationships and exceptions, allowing for flexibility.

Individualism/Communitarianism

Examining the balance between individual desires and group loyalty, the Dutch show a more individualistic tendency, while the Spanish prioritize communal values. Understanding this cultural distinction is vital when working together.

Specific/Diffuse

This dimension concerns how people approach tasks, focusing either on specific details or the bigger picture. The Dutch exhibit a preference for specific, task-oriented behaviour, which contrasts with the Spanish tendency to favour diffuse, relationship-oriented approaches.

Neutral/Affective

Exploring emotional expression and rationality, the Dutch tend to conceal emotions more than the Spanish, who are generally more expressive.

Achievement/Ascription

This dimension delves into how personal status is determined. The Dutch have a stronger inclination toward achievement-based status compared to the Spanish, who may place more emphasis on ascribed characteristics.

Past, Present, Future

The Dutch and Spanish have similar orientations regarding the past, present, and future, which could influence the approach to planning and time management.

Sequential/Synchronic

The Dutch exhibit a greater preference for single-tasking, whereas the Spanish are relatively similar but may engage in more multi-tasking.

Internal/External

The Dutch tend to be more externally controlled, while the Spanish show some similarities in this regard. Understanding these perspectives can aid in adapting strategies and approaches for effective cross-cultural collaboration.

Conclusion

Each dimension offers insights into the cultural values and behaviours of the Dutch and Spanish, enhancing awareness and cooperation in various contexts. For the project group, it is important to keep in mind these cultural differences and adjust the approach to communication with the members.

2.2.2 Hofstede's Cultural Differences

Culture is composed of multiple tiers, and it is frequently likened to a society, as shown in Figure 7. At the outermost layer of this onion, are symbols, encompassing items like cuisine, logos, hues, or notable landmarks. Moving inward, the subsequent layer features heroes, encompassing real-life prominent figures such as statesmen, athletes, or business founders, as well as fictional figures like Superman in the realm of popular culture. In the innermost layer, closest to the core, there are rituals, which may encompass activities like sauna sessions, karaoke gatherings, or formal meetings.

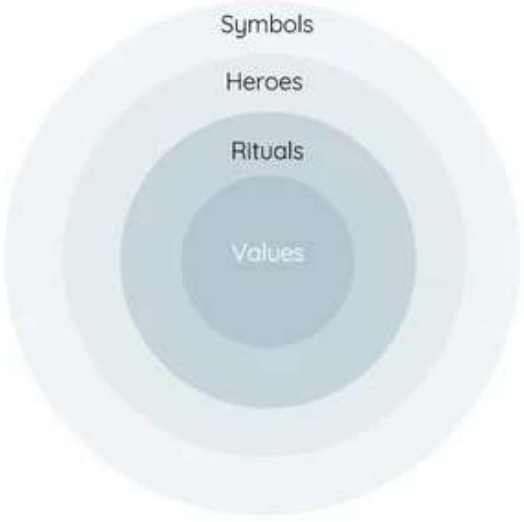


Figure 7. Tiers of Culture. (Hofstede Insights, n.d.).

Deep within the heart of culture lie its values. Values represent overarching inclinations towards specific circumstances or ideals (for example, favouring equality over hierarchy).

Values take root in the surrounding environment, moulding the comprehension of acceptable conduct. The guidance provided by parents or teachers serves as a model for behaviour (Hofstede Insights, n.d.). This is the level where the Hofstede dimensions are part of, as shown in Figure 8.

Figure 8. Comparison of Hofstede's Cultural Differences. (Hofstede Insights, n.d.).

Power Distance

Finland scores 33, reflecting strong individual independence, accessible superiors, coaching leadership, decentralized power, and inclusive communication. The Netherlands scores 38, sharing these traits with a focus on convenience-driven hierarchy and empowerment. Spain scores 57, showing a significant preference for a structured, hierarchical society that does not question authority disparities and values benevolent autocratic leadership.

Individualism

Finland scores 63, signifying an individualistic society where people are primarily responsible individually and collectively. Transgressions result in guilt and lower self-esteem, and the employer-employee relationship is seen as a mutually beneficial contract based on merit, with management focusing on individual support.

The Netherlands scores 80, sharing these traits of individualism with a strong emphasis on personal responsibility, guilt over transgressions, and merit-based decisions in the employer-employee relationship, with management providing individual guidance.

Spain, with a score of 51, exhibits some collectivist characteristics compared to other European nations. However, globally, Spain leans more towards individualism. This dual perspective allows Spaniards to adapt well to different cultures, particularly those outside Europe, which may be seen as more assertive. Collaboration and teamwork are intrinsic to Spanish work culture, with employees often participating without extensive management motivation.

Masculinity

A high score on the Masculine dimension signifies a competitive and achievement-driven society, where success is defined by winners. Finland scores 26, indicating a Feminine society, where the focus is on work-life balance, consensus, equality, and quality. Conflict resolution involves compromise, and well-being is prioritized. Effective managers are supportive, and decisions are made collectively.

The Netherlands also scores 14, classifying it as a Feminine society, emphasizing life-work balance and inclusivity. Managers encourage team members, and decision-making involves everyone. Consensus, equality, and quality are highly valued, with conflict resolution through compromise and lengthy discussions.

Spain scores 42, highlighting a strong focus on consensus and a distaste for excessive competitiveness. Harmony and inclusivity are instilled in children, while sympathy for the weak is encouraged. Managers consult subordinates and consider opinions in decision-

making. In politics, minority participation is sought to avoid one dominant party, contrasting the "winner takes it all" approach.

Uncertainty Avoidance

Finland scores 59, indicating a strong preference for avoiding uncertainty. In such cultures, strict codes of behaviour and resistance to unorthodox ideas are common. There is an emotional need for rules, time is highly valued, hard work is essential, and precision and punctuality are norms. Innovation may be resisted, and security is a significant motivator.

The Netherlands scores 53, reflecting a slight preference for avoiding uncertainty. Similar traits are observed in such cultures, with a need for rules, a focus on time, a strong work ethic, precision, and punctuality. Innovation may face resistance, and security is a key motivator.

Spain scores 86, signifying a profound aversion to uncertainty. Rules and structure are highly valued, and changes cause stress. Confrontation is avoided, leading to a concern for ambiguous situations. Many young Spaniards seek stable, civil service jobs, reflecting a desire for security, in contrast to the more uncertain preferences of American youth.

Long Term Orientation

Finnish culture, with a score of 38, is normative, emphasizing the absolute Truth, tradition, quick results, and a lesser inclination to save.

The Netherlands, scoring 67, exhibits a pragmatic nature, believing truth depends on context, adapting traditions, saving, investing, and valuing thriftiness and perseverance.

Spain, scoring 48, leans towards normative culture. Spaniards prioritize the present over the future, value quick results, and prefer clear structures and rules over a more relaxed, pragmatic approach, especially in the long term.

Indulgence

Finland scores 57, indicating an Indulgent society where people freely realize impulses and enjoy life. Finns hold a positive outlook, value leisure, and spend money when pleased.

The Netherlands scores 68, reflecting a strong Indulgent culture with a similar focus on impulses, fun, positivity, and a high regard for leisure and discretionary spending.

Spain scores 44, showing a Restrained society. Such cultures lean toward cynicism and pessimism, do not prioritize leisure, and control desires. Spaniards feel social norms restrain these actions, and indulgence is viewed as somewhat wrong.

2.3 Sanitizing of Hands Background

Handwashing machines, also known as automated or touchless handwash systems, have become increasingly relevant in recent years due to the role in promoting hygiene and reducing the transmission of diseases, especially during public health crises such as the COVID-19 pandemic.

Handwashing machines have evolved, driven by advancements in technology and an increasing awareness of the importance of hand hygiene.

Early Innovations: The concept of automated handwashing dates back to the late 19th century. In 1889, American inventor Thomas Turner patented a mechanical handwashing apparatus. However, these early inventions were rudimentary and did not gain widespread adoption.

Mid-20th Century: Significant developments occurred in the mid-20th century. In 1952, George H. Ball, an engineer, introduced a touchless handwashing machine known as the "Automatic Glove Washer." These machines were primarily used in healthcare settings and were designed to improve hand hygiene among medical professionals.

Modern Advancements: The 21st century has seen a surge in the development and deployment of advanced handwashing machines. These machines incorporate sophisticated sensor technology, automated soap and water dispensing, and built-in hand dryers. These machines are not limited to healthcare but have expanded to various public and private settings, including airports, restaurants, and commercial facilities.

3 Definition of the Project

Chapter two intricately explores the "Definition of the Project," serving as a blueprint delineating fundamental elements guiding our endeavour within the EPS program in Finland. Central to this chapter is the articulation of Mission and Vision, encapsulating the purpose and long-term aspirations underlying the collaborative pursuit. It meticulously defines the Project Aim and Deliverables, establishing clear objectives and tangible outcomes critical for success. This section navigates through meticulous Planning and Deliverables, crafting a roadmap for execution to ensure timely achievement of project milestones. Additionally, it maps out diverse stakeholders, elucidating their roles, interests, and contributions crucial for seamless project execution. Furthermore, meticulous analysis and address of Project Risks are presented, offering comprehensive assessments and mitigation strategies to navigate potential challenges, ensuring the project's resilience and success. In essence, this section serves as a foundational guide, intricately outlining the project's core elements and strategies for achievement.

3.1 Mission & Vision

The project group's mission is to empower beauty enthusiasts to wholeheartedly pursue passion for makeup, combining artistry with convenience. The members are dedicated to crafting innovative and highly effective makeup hand sanitizers that place the highest priority on the hygiene and well-being of makeup users. The group believes in seamlessly merging beauty and practicality, enabling everyone to freely express a unique style without compromising limited time and health.

The vision of the project group is to lead the way in redefining beauty and hygiene standards. The team envisions a world where makeup enthusiasts can indulge in creative expressions while maintaining ample hygiene. The strive is to be the go-to brand for makeup hand sanitizers, known for quality, innovation, and commitment to the health and beauty of customers. This project group aspires to transform the beauty industry by making convenient and effective beauty sanitization accessible to all daily makeup users.

3.2 Project Aim and Deliverables

After multiple meetings with the customer, it is determined what the aim of the project is. It is formulated like this: “Create a prototype that can clean and dry dirty makeup hands.”

The deliverables to reach this aim are as follows:

- Discover the customer’s needs to define requirements for the hand sanitiser machine within 2 weeks.
- Design the hand sanitiser based on a package of requirements needs before the midterms (30 October).
- Launch one prototype based on the design before the end of the project.

The details of these deliverables are explained in the next paragraph (as seen in Figures 9, 10 and 11).

Furthermore, there are multiple questions formulated to structure the report. The questions include:

Main question:

- How can a neutrally coloured portable prototype be developed that can clean and dry makeup-covered hands without leaving a dry feeling on the skin?

Sub questions:

- What are the needs of the customers in the product?
- How will the prototype be designed?
- How will the prototype be manufactured?
- How will the prototype be tested?

3.3 Planning and Scheduling

In the realm of project management, 'Planning and Scheduling' serves as a crucial guide. It is split into two parts: 'Work Breakdown Structure' and 'Project Scheduling and Responsibilities.' This section breaks down how projects are organized, and the timelines and roles involved. It is like a map, making sure teams know what to do and when, keeping everything running smoothly. Let us explore how tasks are divided up and timelines are set, showing how structured planning leads to successful projects.

3.3.1 Work Breakdown Structure

The first deliverable is D1: Define needs. This deliverable is also the first stage of the project. It is divided into three tasks: Prepare the project, pre-research on project, and create a package of requirements. Additionally. These tasks are divided into subtasks, as shown in Figure 9. The chosen colour red also refers to the Gantt, which can be found in Appendix 2.

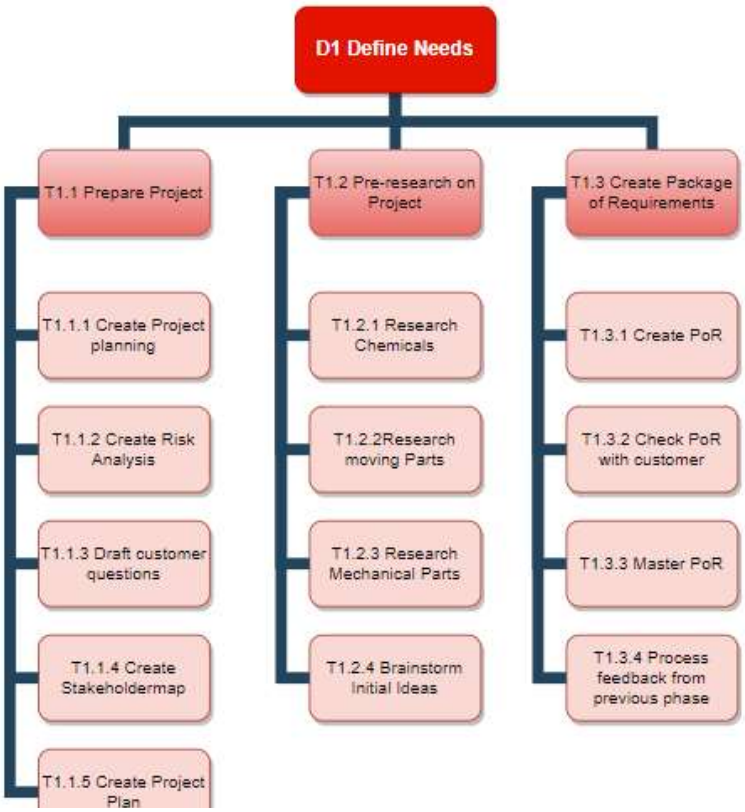


Figure 9. Deliverable 1: Define Needs. (own author).

The second deliverable is the Design Prototype, this deliverable is divided into four tasks. These include Testing Crucial Components, Create Functional Design, Other Design Activities, and Order Parts for Realization. Also, these are divided into subtasks, see Figure 10. This deliverable is coloured blue, which is also the colour of this group of tasks in the Gantt Diagram (appendix 2).

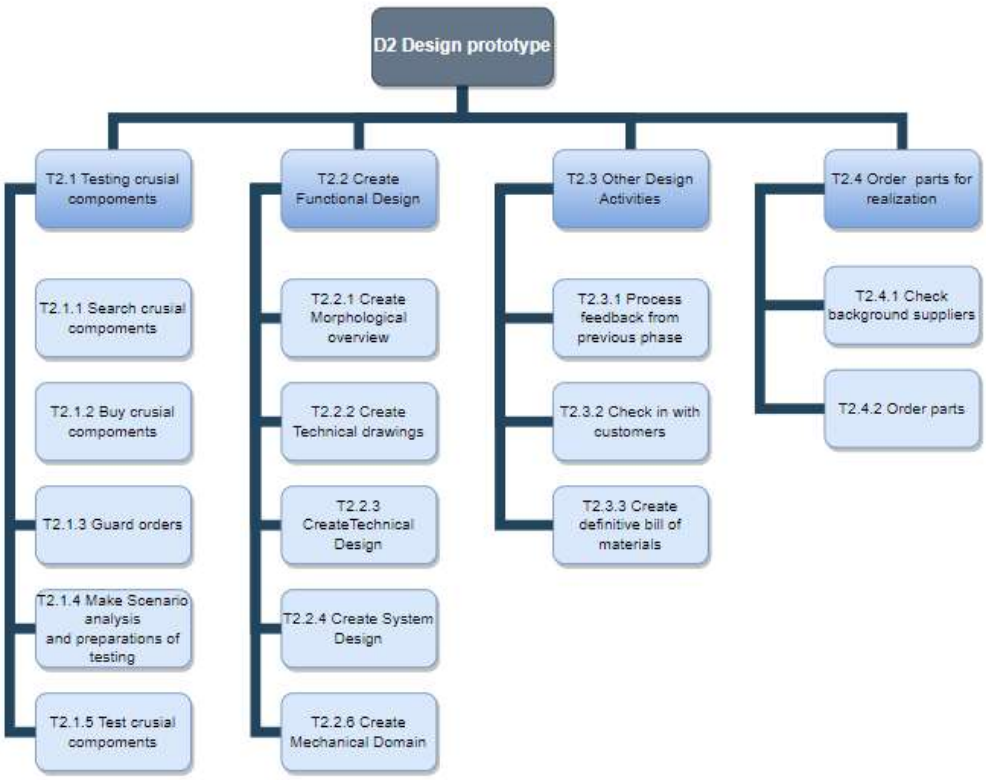


Figure 10. Deliverable 2: Design Prototype. (own author).

The third deliverable is the Test Prototype. This deliverable is bigger than the previous ones, so it is split into six tasks. These tasks moreover consist of multiple subtasks, as shown in Figure 11. Also, the colour is the same as in the Gantt Diagram, like the other deliverables, which can be found in Appendix 2.

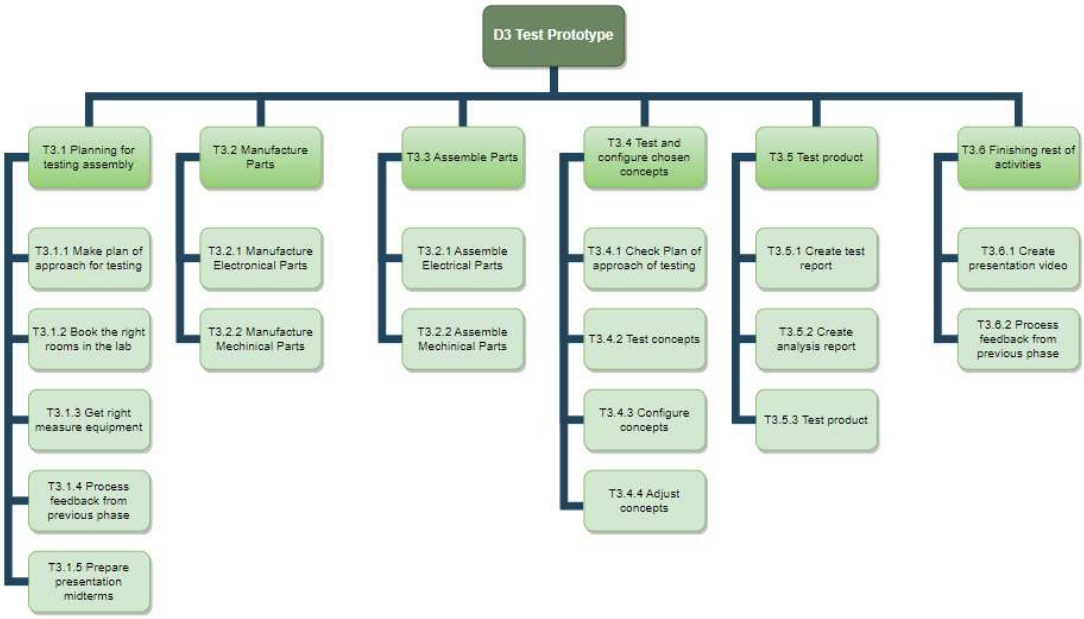


Figure 11. Deliverable 3: Test Prototype. (own author).

3.3.2 Project Scheduling and Responsibilities

A Gantt Diagram provides an overview of what activities need to be done at what time and how these activities correlate. In Appendix 3 the Gantt is shown in Figures 58 and 59 of the whole project, and the colours used for each deliverable relate to the WBS.

3.4 Stakeholders

In the realm of project management, the subchapter on 'Stakeholders' stands as a critical focal point. This section comprises 'Stakeholders' Identification,' 'Stakeholder Analysis,' and 'Communication Plan.' These components lead through the process of recognizing, comprehending, and engaging with various stakeholders who hold significance, influence, and vested interests in the project's success. Delving into this domain unravels the intricate network of relationships, motivations, and communication strategies vital for navigating and ensuring collaborative engagement and alignment, essential elements for project triumph.

3.4.1 Stakeholders' Identification

In Table 1 all stakeholders are mapped with an ID. This ID is used to plot these persons. In Table 1 it is also determined whether the stakeholder is internal or external. Furthermore, the role of the project and the objectives of each stakeholder are mentioned.

Table 1: Stakeholder Identification.

ID	STAKEHOLDER	CATEGORY	ROLE	OBJECTIVES
	Who is involved in the project?	*Internal or external stakeholder?*	*Role of the project?*	*What are the objectives during the project?*
1	Project group	Internal	Project team	project success within scope, time, and budget
2	Josefin Stolpe	Internal	Supervisor	provide guidance, and monitor progress
3	Christina and Isabel Bjon	Internal	Customers	give feedback (developing) prototype
4	Hans Lindén	Internal	Customer and Supervisor	provide technical guidance, order necessary parts
5	Novia University	Internal	Educational Institution	Project results
6	Suppliers	External	Provide components or materials for the project	Deliver components on time and ensure their quality
7	Home universities	External	Concerned with the project's impact on students' grades or academic progress	Receive grades and academic credit for participating students
8	Philip Hollins	External	Giving right information about project management	Guide to make a planning and objectives

(Own author).

3.4.2 Stakeholder Analysis

Also, the stakeholders are analysed at different dimensions, see Table 2. These ratings are spined off in matrixes on the next pages. Firstly, it is about interest next to influence. The higher the score, the higher the priority is from the stakeholder. In addition, trust and agreement are determined per stakeholder. This can indicate the relationship between the project group and the stakeholders. An explanation of these scores can be found in Appendix 5.

Table 2. Stakeholder Analysis.

ID	STAKEHOLDER	INTERESTS	INFLUENCE		TRUST	AGREEMENT
	Who is involved in the project?	*Rate 1 (LOW) to 3 (HIGH)*	*Rate 1 (LOW) to 3 (HIGH)*		*Rate 1 (LOW) to 3 (HIGH)*	*Rate 1 (LOW) to 3 (HIGH)*
1	Project group	3	3		3	3
2	Josefin Stolpe	3	2		3	1
3	Christina and Isabel Bjon	3	2		3	2
4	Hans Lindén	3	2		1	2
5	Novia University	2	1		2	3
6	Suppliers	1	2		1	3
7	Home universities	2	1		3	3
8	Philip Hollins	1	1		2	2

(Own author).

After the stakeholders have been analysed, the Stakeholder Matrix can be used, see Figure 12. This matrix is a project management tool that aids in assessing and prioritizing project stakeholders based on interests and influence. This analysis helps determine the most effective strategies for aligning concerns and expectations with the project's goals and objectives. The most important stakeholders are, the project group itself, so project members need to have regular meetings about various topics (e.g., feedback and project progress). Also, Josefin, Christina and Isabel Bjon, and Hans Linden need to be managed closely. The universities need to be informed when it is needed, more information about this communication is noted in table 3.

Figure 12. Stakeholder Matrix. (own author).

In Figure 13 all the stakeholders are mapped on account of the analysis which is done in Appendix 4. A noteworthy stakeholder is Hans, because this person needs to be managed closely and has low trust and average agreement: a Fence sitter. The rest of the stakeholders (except for the suppliers, which is not a problem) have a high level of trust. The opponents can give critical perspectives on the development of the project, which is needed to get the best results. The allies are the project group itself and the universities, for this, there is no action needed to change this agreement or trust.

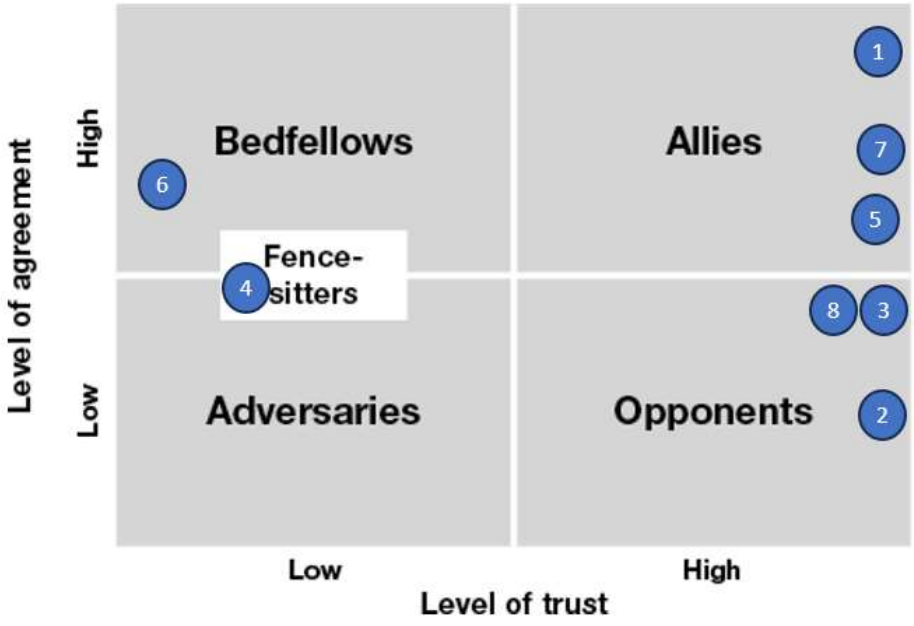


Figure 13. Stakeholder Relations Matrix. (leadershipcentre, n.d.).

3.4.3 Communication Plan

After the analysis from the previous paragraph, a communication plan can be determined. This communication plan consists of contact information per stakeholder, so each stakeholder can be contacted when it is needed. This frequency is noted in the next column. Finally, the approach to communication is described, see Table 3.

Table 3: Communication Plan.

ID	STAKEHOLDER	FREQUENTY	COMMUNICATION APPROACH
	Who is involved in the project?	*How often to provide updates?*	*How to communicate?*
1	Project group	Daily	In person, Whatsapp
2	Josefin Stolpe	Weekly	In person, Microsoft Teams, email
3	Christina and Isabel Bjon	Twice per month	In person, Whatsapp
4	Hans Lindén	Weekly	Microsoft Teams, email
5	Novia University	Twice, midterm and at the end of the project, when necessary	Email
6	Suppliers	When necessary	On Website, email
7	Home universities	Once, at the end of the project	Email
8	Philip Hollins	During lectures	In person, email

(Own author).

3.5 Project Risks

The expansive domain encapsulates 'Project Risks,' a chapter fundamental in the pre-emptive identification, mitigation, and management of uncertainties inherent in project environments. This chapter comprises two pivotal components: 'Risk Register and Responses' and 'Assessment of Business Risk.' Herein lies a meticulous exploration into the systematic process of risk identification, structured documentation within a risk register, and the strategic formulation of responses. Furthermore, it encompasses an in-depth examination of evaluating business risks and analysing their potential impact on project objectives and organizational directives. Embracing these sections facilitates a comprehensive approach, fostering preparedness and adaptive strategies essential in confronting and navigating diverse challenges posed by uncertainties.

3.5.1 Risk Register and Responses

There is a variety of approaches in risk management, as a project manager it is needed to determine which risks are involved in the project. The project manager is responsible for these risks, but the manager is not a specialist in this field. That is why organizations have a risk management department, however, these analyses are complicated, a generalist has to understand what the opinion is from a specialist, which can be quite difficult because experts and specialists speak jargon. That is why a project manager needs to understand basic concepts of risk management (Green, 2016, p. 1).

Firstly, a risk register is created for the internal risks (Table 4). These risks are labelled from A to F. In the next columns, the impact and probability can be found. Impact times the probability is the total risk (Kent, 2016).

Table 4. (Shortened) Internal Risk Register. (own author).

ID	RISK DESCRIPTION	IMPACT LEVEL	PROBABILITY LEVEL	PRIORITY LEVEL
	Give a brief summary of the risk	Rate 1 (LOW) to 5 (HIGH)	Rate 1 (LOW) to 5 (HIGH)	(IMPACT X PROBABILITY) Address the highest first
A	Christina and/or Isabel Bjon are not available	3	2	**6**
B	Insufficient knowledge regarding programs, components or processes	5	3	**15**
C	The delivered components are, when the end product has to be delivered, no longer working	5	1	**5**
D	The delivered components are, when the end product is going to the test phase, no longer working	5	2	**10**
E	The water hits the electronical parts and causes a short circuit	5	4	**20**
F	This prototype carries risks with not containing environmental friendly materials and chemicals.	2	3	**6**

(own author).

Also, the External Risks are identified separately from the internal risks. This is shown in table 5.

In Appendix 5 the full Risk Register can be found, this register also contains the type of risk and the impact description.

Table 5. (Shortened) External Risk Register.

ID	RISK DESCRIPTION	IMPACT LEVEL	PROBABILITY LEVEL	PRIORITY LEVEL
	Give a brief summary of the risk	Rate 1 (LOW) to 5 (HIGH)	Rate 1 (LOW) to 5 (HIGH)	(IMPACT X PROBABILITY) Address the highest first
K	Delivery components delayed	3	2	**6**
L	Components are not available	4	2	**8**

(own author).

The priority of these risks can be mapped in a risk matrix, see Figure 14. This indicates how big the risks are. Risks B, E, and G are the highest. While risks A, H, F, and K are the lowest risks.

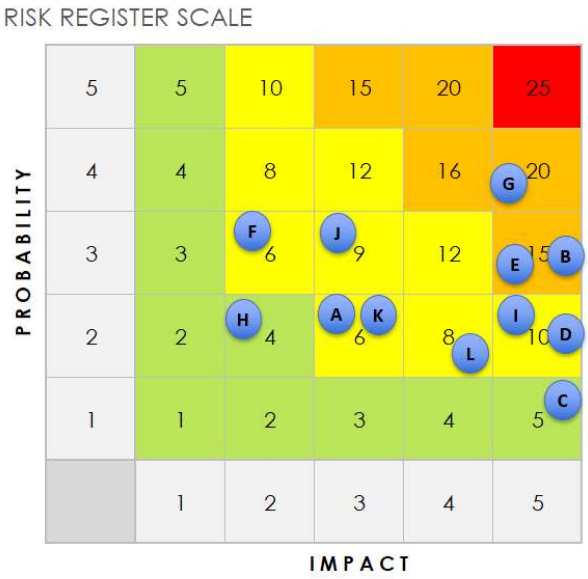


Figure 14. Risk Matrix. (own author).

Figure 15 shows what type of response there will be at any risk. On all risks there will be a response, except for risk H, this risk is small enough to be accepted. It is about legislation of a product; however, the aim of this project is only developing a prototype. The biggest risks will be avoided, this is shown in Figure 18. Risks with high probability and low impact will be reduced. The last category, risks which have a high impact and low probability, will be transferred. Tables 6 and 7 show each response that can be taken regarding risk. The owners of the risks are also determined in these figures.

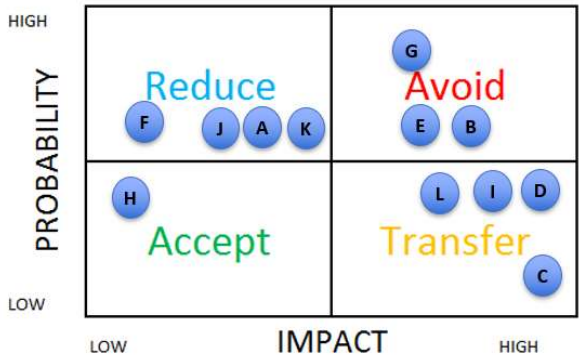


Figure 15. Risk Response. (own author).

Table 6. Internal Risk Response.

ID	RISK DESCRIPTION	RESPONSE NOTES	RESPONSE	OWNER
	Give a brief summary of the risk	What action will the project group take?	Fill in: Accept, Reduce, Transfer, or Avoid	Who's responsible?
A	Christina and/or Isabel Bjon are not available	This risk can be reduced by planning meetings ahead and keeping the customer informed.	**Reduce**	Sabine
B	Insufficient knowledge regarding programs, components or processes	This risk can be avoided by using other programs/products. In addition, there is an opportunity to consult university staff for help or explanation about the problem. As well as desk researching.	**Avoid**	Sabine, Santiago
C	The delivered components are, when the end product has to be delivered, no longer working	The project group can transfer the risk by finding a new supplier in the area of Vaasa.	**Transfer**	Project group
D	The delivered components are, when the end product is going to the test phase, no longer working	The project group can transfer the risk by finding a new components in the area of Vaasa.	**Transfer**	Project group
E	The water hits the electronical parts and causes a short circuit	This can be avoided by making sure that the reservoir is waterproof and the wiring is sealed correctly. Also position the water reservoir at distance from wiring as much as possible, at a proper distance from the electronical parts.	**Avoid**	Sabine, Santiago

(own author).

Table 7. External Risk Responses.

ID	RISK DESCRIPTION	RESPONSE NOTES	RESPONSE	OWNER
	Give a brief summary of the risk	What can be done to lower or eliminate the impact or probability?	Fill in: Accept, Reduce, Transfer, or Avoid	Who's responsible?
K	Delivery components delayed	Reduce the risk by ensuring the due date of the product's delivery is a week before it is needed	**Reduce**	Project group
L	Components are not available	Transfer risk by researching alternative components for the most crucial parts (morphological overview)	**Transfer**	Project group

(own author).

3.5.2 Assessment of Business Risk

The Ansoff Matrix (figure 16), also known as the Product/Market Expansion Grid, is a management framework with a two-by-two structure. It aids management teams and analysts in planning and assessing growth strategies. This tool is particularly useful for visualizing the varying levels of risk linked to different expansion strategies (Peterdy, 2022).

This project is a new product in an existing market. That is why the risk is in the product development segment. This is a mediate risk, diversification has the most risks, while market penetration has the least business risks (Hollins, 2023).

Figure 16. Ansoff Matrix. (Peterdy, 2022).

4 Defining Customers' Needs

The chapter on 'Defining Customers' Needs' represents a comprehensive exploration into the intricate process of understanding and translating customer requisites into actionable project elements. Comprised of segments such as 'List of Definitions,' 'Flowcharts,' 'User Requirements,' 'Functional Description,' 'Technical Requirements,' 'System Test Plan,' and 'Critical Analysis of the Requirements,' this chapter delves into the methodologies and tools employed in delineating and structuring customer needs. From establishing terminology and visual representations to detailing user and technical specifications, this chapter rigorously synthesizes diverse inputs to create a cohesive project blueprint. The culminating critical analysis ensures alignment, feasibility, and adherence to overarching project goals.

4.1 Flowcharts

Through a series of various symbols, flowcharts help to visually illustrate the steps, decisions, and flow of information within a process. In this section, flowcharts for the user interaction and the machine automatisms are shown.

4.1.1 User Interaction Flowchart

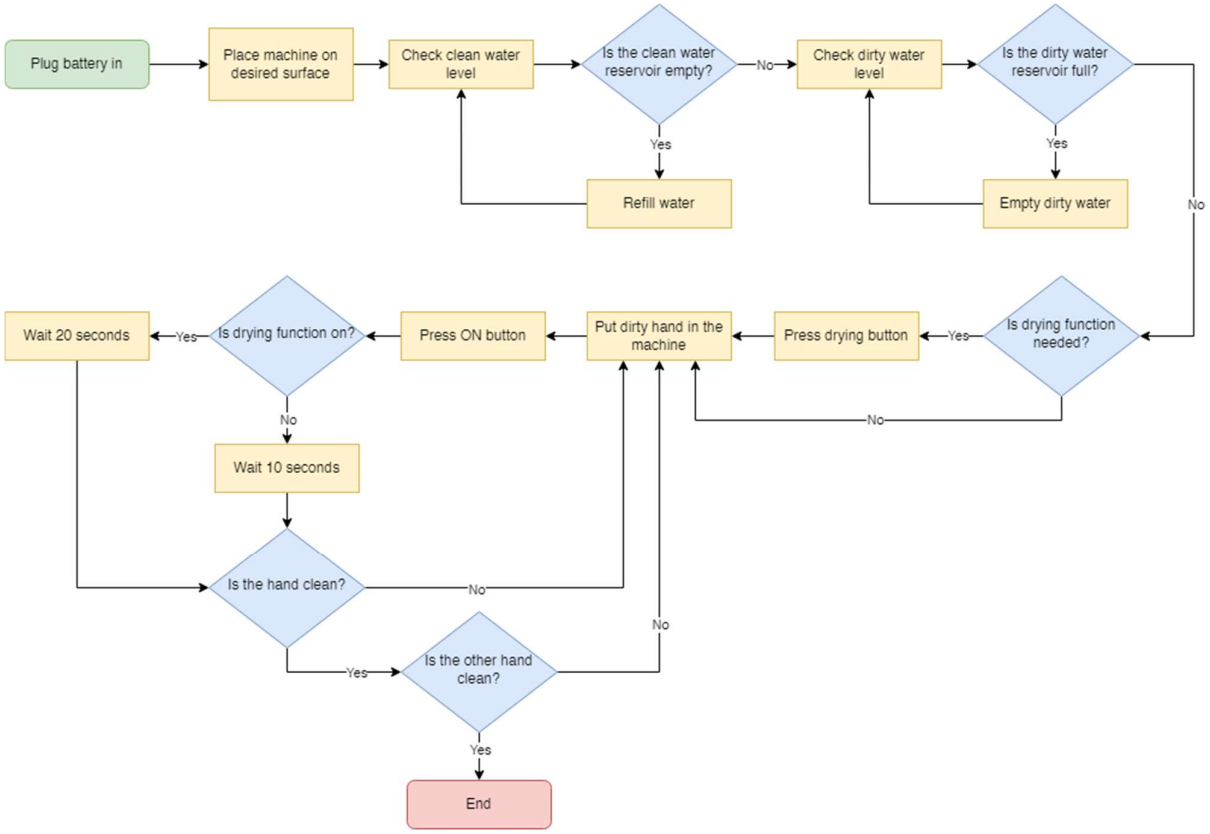


Figure 17. Flowchart of Use. (own author).

This first flowchart shown in Figure 17 is used to overview the detailed series of steps that a user must follow to operate the device. It has been optimized to minimize the number of actions the user must perform, to comply with the desire of our client regarding ease of use.

Figure 18. On Switch and Drying Button. (own Author).

The two buttons mentioned in the flowchart are placed on the superior part of the machine, where the user can easily access them. The ON/OFF button, larger in size, is the one that starts the cleaning process when pressed. The drying selector button functions the same way the Caps Lock" button on a keyboard does and determines if the drying process will be executed or not after the cleaning process.

4.1.2 Technical Flowchart

The flowchart shown in Figure 19 gives a comprehension of the internal processes happening within the machine as the user interacts with it.

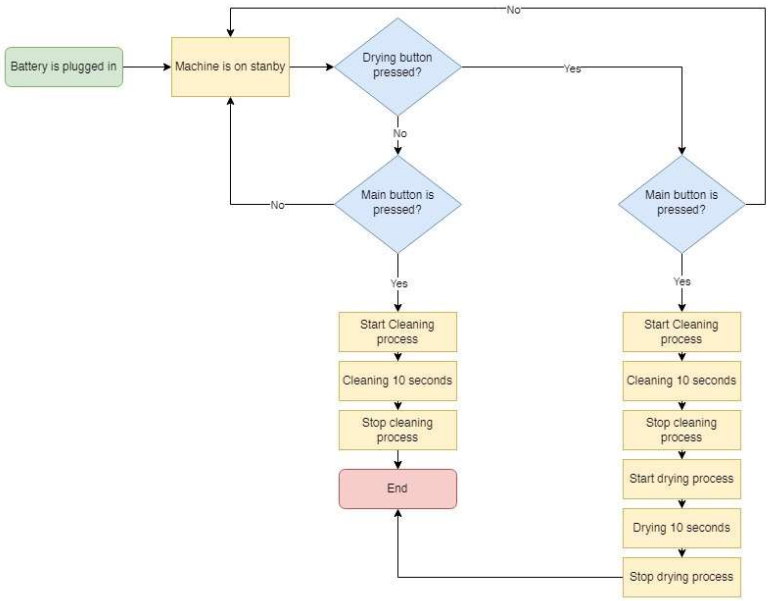


Figure 19. Technical Flowchart. (own author).

4.2 User Requirements

To have a better understanding of what is the expected result of the project, a package of requirements has been written and discussed between the group members and the clients.

Based on a basic package of requirements that the team solicited from the clients, a more complete package of requirements was written. This version was shown to the clients, and after their approval, it has been the one used as a guide for the development of the project. The definitions of this package of requirements are in Table 8 and Table 9.

Table 8. List of definitions Chapter 3.

MoSCoW: Must have Should have Could have Won't have. The Moscow prioritizing is used to prioritize the functions of the product.
M: Must have: The system cannot work without it.
S: Should have: preferable, but not essential
C: Could have: good to have, but not a priority, only implemented if there is time.
W: Won't have: requirements will not be implemented but are interesting for further development.
Test types: Demonstration → **D** Test → **T** Analysis → **A**

(own author).

Table 9. User Requirements.

Number	Requirements	Minimum/ maximum / equal to	Value	Unit	MoSCoW	Type test
UR0101	The system must be able to clean the hands	Equal to	True	True/False	M	D
UR0102	The system must be able to dry the hands	Equal to	True	True/False	M	D
UR0103	The colours must be neutral (Beige, Black)	Equal to	Beige/ black	Colour	M	D
UR0104	The cleaning process must not leave the user's skin feeling dry	Equal to	True	True/ False	M	T
UR0104	The product must be portable	Equal to	True	True/False	M	D
UR0105	The product must not cost more than €200	Max	200	Euros	M	A
UR0106	The product must be stable on the surface on which it is standing on	Equal to	True	True/False	M	D
UR0107	The product could be round	Equal to	True	True/False	C	D
UR0108	The product could disinfect the skin	Equal to	True	True/False	C	T
UR0110	The product could have a bag in which it could be stored in	Equal to	True	True/False	C	D
UR0111	The product won't have a water heater	Equal to	True	True/False	W	A
UR0112	The product won't have a self-cleaning function	Equal to	True	True/False	W	A
UR0113	The product could be turned on by a sensor-based system	Equal to	True	True/False	C	A
UR0114	The product won't be able to clean two hands at once	Equal to	True	True/False	W	A
UR0115	The product will not have a see-through window	Equal to	True	True/False	W	A

(own author).

4.3 Functional Description

To meet the characteristics described in the package of requirements, the product must have the capacity to efficiently clean and dry the user's hands. This would be done by using a friction-based cleaning system, with scrubbers or brushes of some sort, that would work in combination with a suitable cleaning solution. The drying phase would use air, that would be directed at the user's hand while it's still inside the product.

The product would be turned on by actioning a button/switch/dial (yet to decide), which would start the cleaning process. Then, the user would put a hand in the machine, and when the customer considers that it is clean, a second button/switch/dial is actioned to start the drying phase. The process is repeated for the other hand.

There will be two separate compartments, one for the cleaning solution and one for the water. These will be easily accessible and will have maximum and minimum markings to let the user know how much of each is needed.

To make the maintenance and cleaning simpler, it will be easy to remove the necessary pieces to access the insides of the product. There will be a charging port in which the cable will be plugged to charge the machine.

Table 10. Limits of Use Requirements.

Number	Requirement	Minimum/ Maximum / Equal to	Value	Unit
FR0101	The battery will last for a certain amount of sessions	Minimum	14	Sessions
FR0102	The water container will last for a certain amount of sessions	Minimum	14	Sessions

2 times usage is 1 session. So the user can clean both hands in one session. So it is taken into account that the user utilizes the machine for 2 sessions each day.

4.4 Technical Requirements

This series of requirements defines the physical dimensions and characteristics of the machine, which affect its usability as well as the aesthetics.

Table 11. Technical Requirements.

Number	Requirement	Minimum/ Maximum/ Equal to	Value	Unit
TR0101	The Device has a weight	Maximum	5	kg
TR0102	The Device has a height	Maximum	25	Cm
TR0103	The Device has a diameter	Maximum	35	Cm
TR0104	The Device has a few switches	Maximum	3	Switches

(own author).

4.5 Selection of 5 CTQs

Five Critical-to-Quality (CTQ) points have been selected (see Table 12) as these are pivotal factors for an efficient and user-friendly makeup removal system. The initial three pertain to functionality, while the last two specifically address user-friendliness.

Table 12. CTQs.

CTQ	Description
CTQ 1	The system must be able to clean the hands. (UR0101)
CTQ 2	The system must be able to dry the hands. (UR0102)
CTQ 3	The system must be portable. (UR0104)
CTQ 4	The battery will last for a certain amount of sessions. (FE0101)
CTQ 5	The colours must be neutral. (UR0103)

(Own author).

4.6 System Test Plan

To check whether the digital design is functional in its physical form and evaluate if the CTQ points are met, a test plan has been written to be executed later on when the prototype is ready.

The first test regards the hand-cleaning function, which is related to CTQ 1. When the main functional parts that do the cleaning are assembled, the group members will test them by themselves to check for correct functionality. If this is not the case, the machine must be adjusted as needed. When the prototype is finished, this test will be done again to ensure its validity.

The machine should also dry the hands properly. The hands have to be completely dry after they are taken out of the device, as stated in CTQ 2. If the hands do not come out completely dry, the machine should be calibrated as needed. It is also possible that the air blowers are not powerful enough. In such cases, more research should be done in this area.

User requirement UR0104 requires the machine to be portable. This is linked to technical requirement TR0101, which states the maximum weight of the device. To test compliance with both, the prototype will be weighed. If its mass exceeds the maximum stated, the team will consider different options to reduce the weight of the product and ensure that CTQ 3 is correctly addressed.

To verify compliance with CTQ 4, the machine will be used for several cycles. The machine will be tested for the number of sessions stated in functional requirements FR0101 and FR0102. If the battery and water reserves last for a value of sessions equal to or higher than the required, the prototype will be valid. If not, the battery and water efficiency and capacity should be revised.

To make sure that the machine will blend in with the makeup table, the colour of the machine has to be neutral. To test user requirement UR0103, the prototype will be put on a makeup artist's worktable, and the team will evaluate the correctness of the colour. This test is related to CTQ 5.

4.7 Critical Analysis of the Requirements

Several challenges must be addressed in response to the package of requirements. First, there is the issue of drying. Most drying components are non-reusable or occupy a significant amount of space. Additionally, there is the challenge of ensuring that the user's skin does not become dry when removing the hand. The requirements prioritize a convenient and swift process.

The remaining requirements are easily attainable and feasible to implement for this project.

5 Design Prototype

The chapter dedicated to 'Design Prototype' is centred around the core aspect of 'Functional Design.' Within this section, the chapter encapsulates the essence of innovation and developmental processes, specifically honing in on the creation and refinement of prototypes. It emphasizes the functional dimension, delving deeply into the intricacies involved in crafting models that not only encapsulate conceptual ideas but also translate them into tangible, operational designs. The exploration of 'Functional Design' in this chapter, serves as a fundamental cornerstone, shedding light on the journey from ideation to the actualization of practical and functional prototypes.

5.1 Design & Test Crucial Components

The chapter on 'Design & Test Crucial Components' serves as a comprehensive guide delineating the processes involved in the creation and validation of pivotal elements within a project. This chapter comprises three integral segments: 'Brainstorming,' 'Provide Crucial Components,' and 'Testing of Crucial Components.'

Beginning with the phase of 'Brainstorming,' this section explores the dynamic generation of ideas and concepts crucial to the design process. Subsequently, 'Provide Crucial Components' dives into the actual crafting and development of these identified vital elements. Lastly, 'Testing of Crucial Components' focuses on the rigorous examination and validation of these components, ensuring their functionality and reliability.

Through this chapter, readers gain insights into the iterative journey of conceptualization, creation, and validation of critical project components, underscoring the importance of meticulous design and thorough testing in ensuring project success.

5.1.1 Brainstorming

In the project, members conducted a series of brainstorming sessions to outline the product's requirements and find effective solutions to various challenges (see Figure 20).

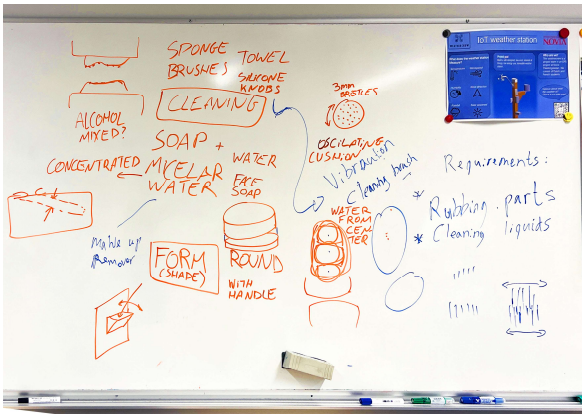


Figure 20. First Brainstorm Session. (own author).

In the first brainstorming session, the group discussed important aspects such as the types of soaps that could be used. This allowed the recognition of the significance of selecting soap varieties that strike a balance between effectiveness and skin-friendliness, ensuring the product is not harmful to the user and does not dry out the skin on the hands like it is stated in the requirements.

Deliberation also took place on the most user-friendly hand brush options, which provided crucial insights into user comfort and safety, informing the understanding that the choice of brush material and design could have a significant impact on the product's overall appeal and effectiveness. Members considered using small oval-shaped silicone pads positioned in arrays alongside the top and the bottom of the hand.

Furthermore, the group has figured out how to integrate these brushes into the machine, offering a perspective on the machine's mechanics and maintenance requirements. The scrubbers will be moved by attaching these to the heads of toothbrushes. Discussing the machine's design led to an understanding of the importance of aesthetics and ergonomics, influencing its usability and marketability.

Considering methods for refilling water reservoirs was also an essential part of the discussion, highlighting the significance of user convenience and efficiency in daily usage.

It was suggested that a small window or opening of some sort could be opened and used to refill the water.

Additionally, a discussion took place about the part where the user inserts the hand. Consideration was given to how the user would interact with the machine and what considerations would be made to ensure the user's safety. It was concluded that placement in a comfortable place and angle would be necessary.

It was also made clear that the shape of the machine would be round.

In the subsequent brainstorming session, attention was turned to the usage sequence and user interface elements. Deliberating on the buttons users would interact with taught valuable lessons about the importance of a user-friendly interface and efficient operation. Exploring various brush options in terms of shapes and materials revealed the potential for customization for fields other than make-up (such as agricultural) and user preference.

The ideas generated for the buttons (see Figures 21 & 22), which were later presented to clients in a meeting, converged in making a selector in the form of a dial which could be placed in three different ways: "turn on", "turn off" and "only clean" (no drying). In the end, this idea did not make it into the final design, as the clients wanted it done differently.

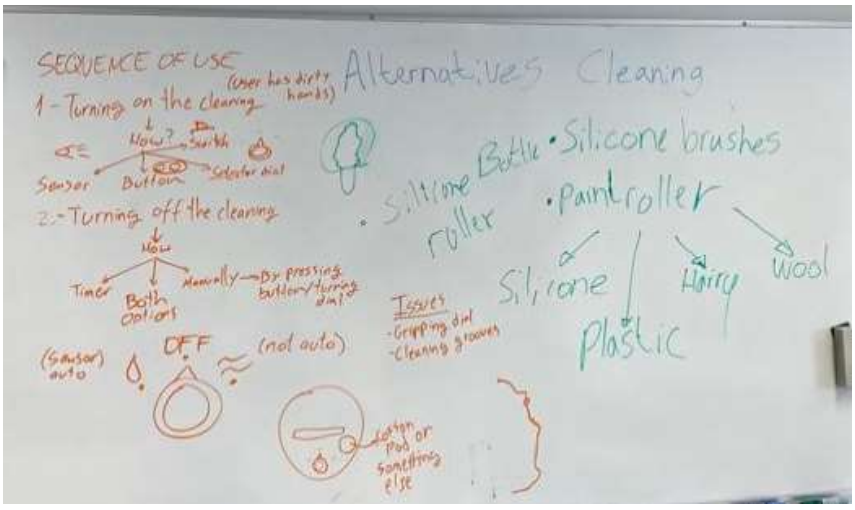


Figure 21. Second Brainstorm Session. (own author).

Discussions on button placement and quantity demonstrated the importance of intuitive and accessible controls. While considering the inclusion of sensors encouraged the exploration of automation and smart features, improving the user experience. In the end, it was determined that a sensor to start the cleaning process automatically would be too complicated to implement, so the idea was discarded.

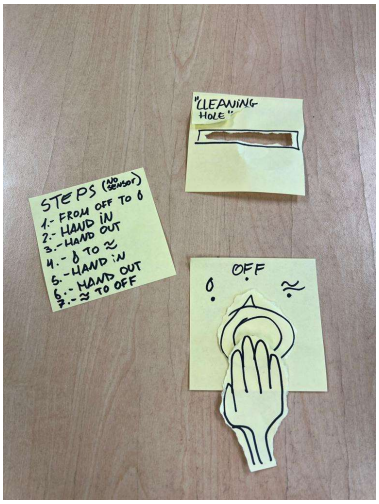


Figure 22. Brainstorming Use of Dial. (own author).

A small-scale model with paper buttons was also constructed to better visualize how the user would interact with the machine, aiding in refining the product concept and design. On a sticky note, step-by-step instructions for the sequence of use were written.

Apart from that, reference pictures of similar machines, like the Roomba floor cleaner, were sought to see how the different components were distributed inside the machine.

In essence, comprehensive brainstorming sessions not only provided a clear direction for product development but also imparted valuable lessons on how to create a user-friendly, efficient, and safe product that caters to a diverse range of user needs.

5.1.2 Provide Crucial Components

In delivering the essential components for the MakeUp Artist Hand Sanitizer, the focus lies on integrating two crucial features—bristles for scrubbing and a water distribution system. These elements work in tandem to not only remove makeup residue from the hands but also facilitate the subsequent drying. However, recognizing the insufficiency of water alone for thorough hand cleaning, the device accommodates the addition of soap or makeup remover to ensure the effective elimination of makeup residues, leaving the hands adequately moist.

The subsequent stage involves the thoughtful consideration of methods to effectively dry the hands post-cleaning. This aspect of the product requires additional fine-tuning to determine the most effective approach for efficiently achieving both cleanliness and dryness.

Figure 23. Logo Solid Works. (https://www.solidworks.com).

The development of the MakeUp Artist Hand Sanitizer embarks on a comprehensive design journey, commencing from a foundational conceptualization. To seamlessly integrate into a makeup environment, the product necessitates a compact and aesthetically pleasing design, harmonizing seamlessly with the makeup table. The device's design will be done via SolidWorks (Figure 23). The realization of this innovative concept hinges on the careful consideration of various factors, encompassing material selection, ergonomic design, power source determination for drying mechanisms, ease of maintenance, user interface design, safety features, adherence to regulations, cost analysis, and a well-crafted marketing strategy.

The development of the MakeUp Artist Hand Sanitizer holds significant promise in streamlining and enhancing the makeup application process. To fully unlock this potential, a thorough exploration through in-depth research, thoughtful design iterations, rigorous testing, and the implementation of an effective marketing strategy becomes imperative. These combined efforts will be crucial in turning the initial idea of the MakeUp Artist Hand Sanitizer into a real and must-have solution for makeup enthusiasts.

5.1.3 Testing of Crucial Components

To test the crucial components, there have been a few prototypes to put the silicone scrubber on the toothbrush head. Glueing or melting it together did not work, but making a holder with the 3D printer to put the scrubber in did work. The toothbrushes have also been taken apart so that there can work on the battery itself and connect multiple motors to one battery. Once this worked, the theory of putting multiple motors on one battery was accepted.

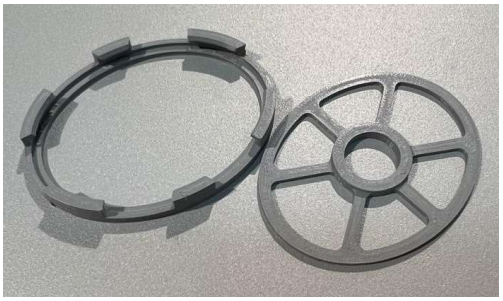


Figure 24. Silicone Holder. (own author).

The blow dryers also need to be connected to the battery later on. To test if the blow dryers will be strong enough for this application, these have been connected to an energy source. The amperage was not given so this had to be figured out. After doing this, it was stated that both worked. To know if these were strong enough, this was tested with a wet hand and holding it between the two blow dryers. If the hand is on an angle between the blow dryers, it imitates the blow-drying function in the machine. After a few seconds, the hand

Figure 25. Testing Scrubber Device. (own author).

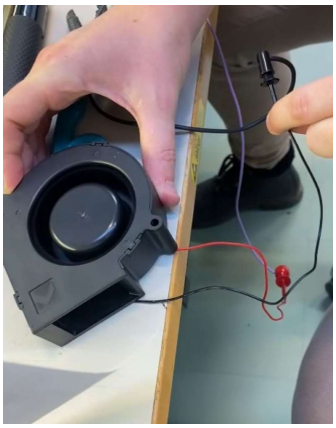


Figure 26. Testing Blow dryer. (own author).

was dry enough to be accepted as a fully dried hand. So, it could be stated that the blow dryers will be successful in the machine.

To transfer the water from the water tank to the bristles, there has to be a water pump. To find a suitable pump, the project group ordered 3 different pumps. The underwater pump did work well, but after some good consideration, it has been denied as a suitable option. This is because it has to be underwater at all times when turned on. This means that the water can never be on a low level or even run out. To make sure that the machine can handle 13 sessions, the water tank should be bigger and that was not a suitable option. The second water pump was peristaltic. After putting water in the pump and turning it on, it was shown that the water came out in shots instead of a steady flow. This is not suitable for this project, because there should be a constant flow of water when it is needed. The last option was the diaphragm pump. This can be outside the water tank and gives water a steady flow. Considering the other two options, the diaphragm pump was the best solution. To integrate this into the machine, there are two pumps needed. One pump transfers the clean water to the scrubbers and one pump transfers the dirty water from the bottom of the machine to the second water tank.

5.2 Functional Design

The subchapter 'Functional Design' constitutes a comprehensive examination of essential methodologies and components pivotal to the development of functional elements within the project. This section encompasses diverse segments, including the 'Kano Model,' 'Function Tree,' 'Morphological Overview,' 'Initial Technical Design,' 'Adjusted Technical Design,' 'Electrical System,' 'Program Code,' and 'Bill of Materials,' collectively forming an expansive framework.

The 'Kano Model' delineates varying customer preferences, while the 'Function Tree' systematically dissects functionalities. The 'Morphological Overview' integrates diverse elements into comprehensive solutions. Successive stages of 'Initial and Adjusted Technical Design' refine and evolve the technical blueprint. The 'Electrical System' addresses the crucial energy aspect, and the 'Program Code' facilitates the functional implementation. Lastly, the 'Bill of Materials' specifies the requisite components.

This subchapter functions as an extensive resource, guiding through intricate stages of design, coding, and material identification, facilitating the development of robust and functional project components.

5.2.1 Kano Model

The Kano Model (Figure 27), phonetically pronounced as "Kah-no," represents an approach for the strategic prioritization of features on a product roadmap. It hinges upon the assessment of each feature's potential to satisfy customers. This evaluation aids product teams in making informed decisions regarding the inclusion of features in the roadmap.

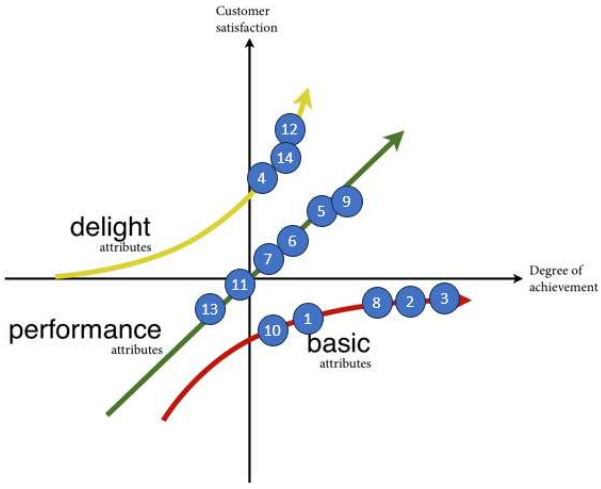


Figure 27. Kano Model. (own author).

The device is portable (1): This feature falls into the "Basic Needs" category because customers expect a portable hand-cleaning and drying device. It is a fundamental requirement for the device to be considered useful.

Device can clean hands (2): Hand cleaning is a core function of the device, and its absence would lead to extreme dissatisfaction. Hence, it belongs to the "Basic Needs" category.

Number	Features	Emotional Response
1	Device is portable	Basic
2	Device can clean hands	Basic
3	Device can dry hands	Basic
4	Device contains a handle	Delight
5	Device contains convenient interface	Performance
6	Device is nice looking	Performance
7	Device is storable	Performance
8	Product is affordable	Basic
9	Device provides a light	Performance
10	Device can be used a week long without recharging	Basic
11	Device can be used as power bank	Performance
12	Device provides a little storage for basic makeup (equipment)	Delight
13	Device contains a hook fastener, to optionally attach a belt	Performance
14	Device contains a pump with moisturizing cream	Delight

Figure 28. Overview Features. (own author).

The device can dry hands (3): Similar to hand cleaning, hand drying is also a fundamental requirement for a hand-cleaning device. Its absence would lead to significant dissatisfaction, placing it in the "Basic Needs" category.

The device contains a handle (4): The presence of a handle, while not a fundamental requirement, can provide added value and user delight. This feature falls into the "Delighter" category because it goes beyond customers' basic expectations.

The device has a convenient interface (5): A convenient interface enhances the device's usability, but its absence may not lead to extreme dissatisfaction. This feature belongs to the "Performance Needs" category as it enhances overall satisfaction.

The device is nice looking (6): Aesthetics contribute to overall user satisfaction, making this feature a "Performance Need." While not as critical as basic functionality, it enhances the user experience.

The device is storable (7): Easy storage contributes to the device's usability, but its absence would not lead to extreme dissatisfaction. It falls into the "Performance Needs" category.

Product is affordable (8): Affordability is a basic requirement for most customers. If the device is unreasonably expensive, it would lead to dissatisfaction. Therefore, it falls into the "Basic Needs" category.

The device provides a light (9): The provision of light enhances the user experience but is not a fundamental requirement. It belongs to the "Performance Needs" category.

The device can be used for a week without recharging (10): Extended battery life is a basic requirement for user satisfaction. If the device frequently requires recharging, it will lead to dissatisfaction, placing it in the "Basic Needs" category.

The device can be used as a power bank (11): This feature enhances the device's versatility and usefulness, but its absence may not lead to extreme dissatisfaction. It falls into the "Performance Needs" category.

The device provides a little storage for basic makeup (equipment) (12): The provision of storage for makeup equipment is an added value and contributes to user delight. This feature falls into the "Delighter" category.

The device has a hook fastener to optionally attach a belt (13): The presence of a hook fastener enhances the device's usability but is not a fundamental requirement. It belongs to the "Performance Needs" category.

The Device contains a pump with moisturizing cream (14): A pump with moisturizing cream is a delightful addition that goes beyond basic expectations. This feature falls into the "Delighter" category.

5.2.2 Function Tree

The function tree as shown in Figure 29 indicates the product's end functions. It is needed to brainstorm solutions for any of these end functions. De decisions will be shown in the Morphological Overview in the next paragraph.

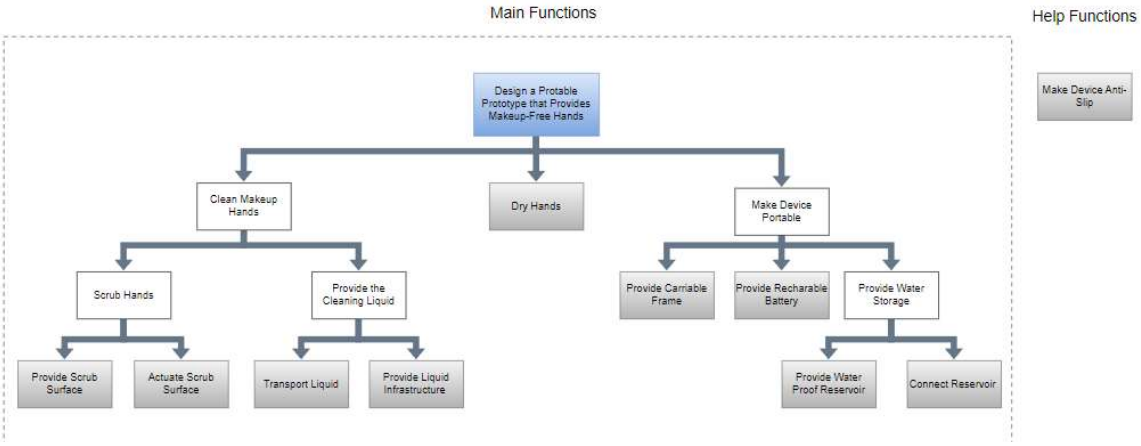


Figure 29. Function Tree. (own author).

The main function of the product is described in Figure 29. This main function is to 'Design a Prototype that provides Makeup-Free Hands. This function is divided into three sub-functions. These functions are: 'Clean makeup Hands', 'Dry Hands', and 'Make Device Portable'. 'Clean Makeup Hands is split into two functions, which spin off into four different functions. These are marked grey. The functions contain 'Provide Scrub Surface', 'Actuate Scrub Surface', 'Transport Liquid', and 'Provide Liquid Infrastructure'. Secondly, the function 'Dry Hands' stands on its own. The function 'Make Device Portable' is divided into four end functions: 'Provide Carriable Frame', 'Provide Rechargeable Battery', 'Provide Waterproof Reservoir', and 'Connect Reservoir'. Separately there is an autonomous help function: 'Make Device Anti-Slip'.

5.2.3 Morphological Overview

Various functions have been prepared for the design of the system. Several ideas/solutions have been devised for all functions. These ideas/solutions have been further incorporated into a morphological overview. The morphological overview can be found below, see Figure 28. The Legenda can be found in Table 13.

Table 13. Legenda Morphological Overview.

Draft 1:	Cheapest
Draft 2:	Durable
Daft 3:	Most Convenient

(own author).

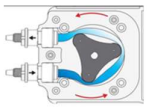
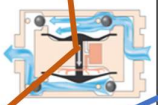
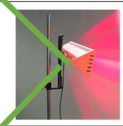
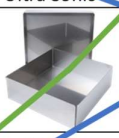
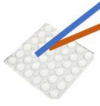
Functions	Option 1	Option 2	Option 3
Provide Scrub Surface			
	Silicone Pads	Silicone Brush	Roller Brush
Actuate Scrub Surface			
	DC	*Stepper*	*Servo*
Transport Liquid			
	Peristalic	Diaphragm	Submersible
Provide Liquid Infrastructure			
	Silicone	PVC	PE
Dry Hands			
	Blowdryer	Ultra Sonic	Infra Red
Provide Carriable Frame			
	3-D Printed	Metal	Plastic
Provide Rechargeable Battery			
	Li-Ion	LiPo	NiMH
Provide Water Proof Reservoir			
	Waterproof Spray	Water Liner	Water Bag
Connect Reservoir			
	Water Valve	Water Tube	Water Lock
Make Device Anti-Slip			
	Silicone	Rubber	Suction Cup

Figure 30. Morphological Overview. (own author).

Motivation per Function

Each function has been provided a solution. Additionally, these solutions are explained.

Firstly, the function 'Provide Scrub Surface' has been chosen for the silicone pads. These are the most functional and feasible for cleaning the hands. Also, these are suitable to integrate and be replaced in the system when needed. This product can be mass-produced so the costs for production are low.

The second function is 'Actuate Scrub Surface'. The stepper motor came up as a solution for this function because the functionality is better compared to the DC and Servo motors, due to the movement a stepper motor can make along with the programming possibilities. In addition, feasibility and sustainability are also aspects which determined the choice of this product. These motors can last 10.000 hours (Anaheim Automation, n.d.).

Thirdly, the function 'Transport Liquid' will be fulfilled with the diaphragm pump solution. It is by far the most functional pump. After testing the peristaltic pump gave 'shots' of water. The submersible pump has to be inside the water at all times, which means that the water tank has to be bigger and cannot be empty at all times. To conclude, considering additional factors, the diaphragm pump would give the best results.

Subsequently, a solution for the function 'Provide Liquid Infrastructure' in the silicone tubes was chosen. These are better to integrate due to the flexibility. The cost is comparable to the PVC pipes with this in mind, these are more commonly used than PE pipes which makes this solution more convenient to work with.

Following, the function ‘Dry Hands’ has as the chosen solution, is the blow dryer. The other solutions as ultrasonic and infrared are significantly more expensive compared to the blow dryer. It has also been implemented in various machines which require drying. This means that there has already been a lot of research conducted. Chosen for the prototype is to utilize a cold air blower for the following reasons:

- Energy Efficiency: Cold hand dryers typically consume less energy compared to warm hand dryers, contributing to lower operational costs and reduced environmental impact.
- Less Potential for Bacteria Growth: Warm air dryers, due to their warm environment, might foster bacterial growth. Cold air dryers may present a reduced risk in this regard.
- Less risk of skin irritation: it is essential to note that hot air blowers, commonly found in warm hand dryers, have the potential to dry out the skin due to the high temperature of the air. This drying effect may cause discomfort or irritation, particularly for individuals with sensitive skin or existing skin conditions. Cold air dryers, by contrast, avoid this concern as they do not subject the skin to high temperatures, offering a gentler and more skin-friendly drying experience.

Above all, the function ‘Provide Carriable Frame’ can be fulfilled with 3-D Printing. This will make the frame look smooth and good-looking. As this was one of the main demands from the customers, this had a big impact. It is also really good to integrate holders for wires or tubes in there. This makes the 3-D printing the best solution.

Subsequently or the function ‘Provide Rechargeable Battery’, the solution that has been chosen is the Li-Ion battery. This battery has the best functionality to integrate into this machine. Nevertheless the similarities with the LiPo battery.

Following, to fulfil the function 'Provide waterproof reservoir' waterproof coating is chosen. This is an adjustable idea and can fit in any shape and size. When there is a leak in the reservoir, it is also easy to fix.

Above all, the function 'Connect Reservoir' has as the chosen solution, the water lock. This lock makes sure that when it is connected, the water can flow to the tubes where it should go. But when the reservoir is disconnected from the main machine, the water will not leak out. It is also easy to replace when necessary.

Last but not least, the function 'Make Device Anti-Slip' will be provided via silicone anti-slip pads. After research, these pads work better, because of the ease of cleaning.

Motivation

With the morphological overview as a tool, there are three solutions from which one draft version has been chosen. To ensure that the chosen solution is the best, assessment tables have been drawn up in which the solutions are weighed based on four different criteria (functionality, feasibility, sustainability and price). These criteria have a percentage that indicates which ones carry the most weight and are therefore the most important for the project.

After all possible solutions were assessed (per function), it turned out that solution 1 achieved the highest score.

5.2.4 Initial Technical Design

The machine is composed of a series of components that work together to make it function as intended.

Case

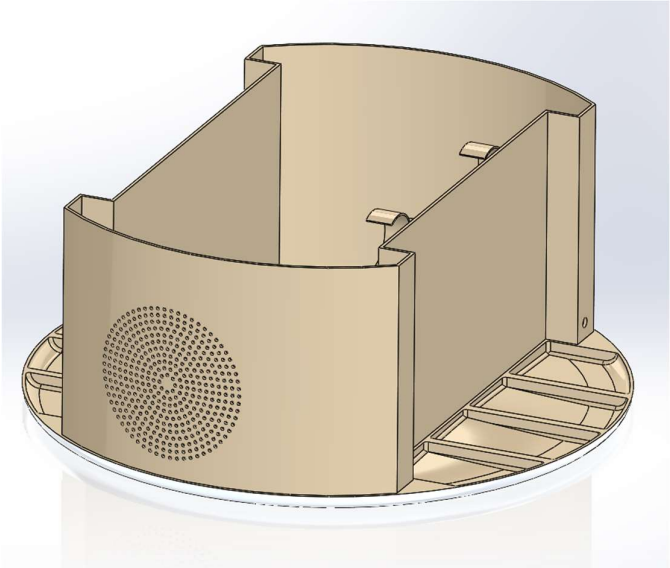


Figure 31. Main Frame. (own author).

First is the case. It is the main chassis, on which the rest of the components will be mounted. It is composed of one piece that has a series of features:

- **Air intake holes.** These serve as a way for the air to get from the exterior of the machine to one of the hand-drying fans.

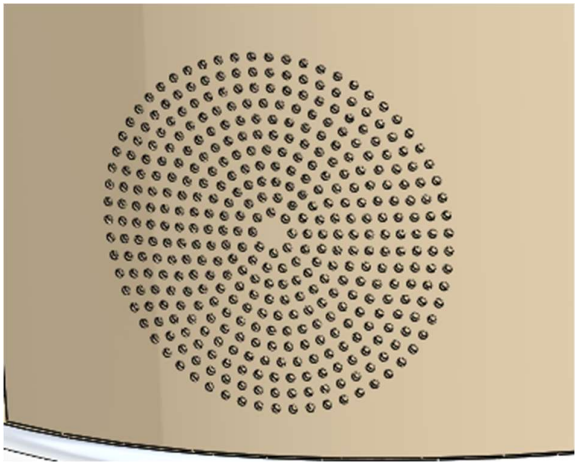


Figure 32. Air Intake Holes. (own author).

- **Water pump holder clips.** Both water pumps are in place.

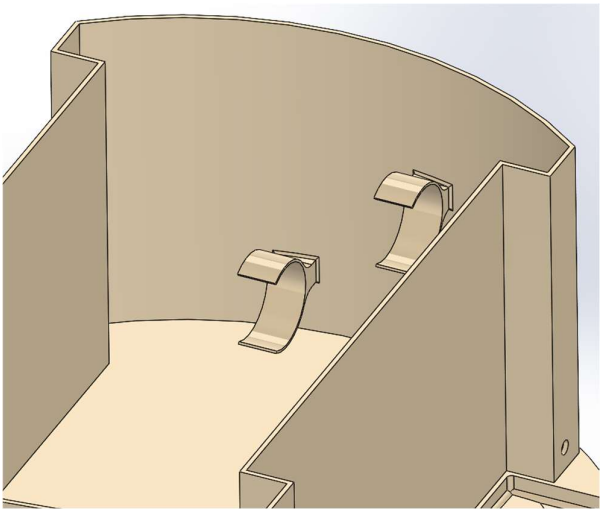


Figure 33. Water Pump Clips. (own author).

- **Holes.** These are placed on both sides and are used for connecting the pumps to the water reservoirs. In the future, it is planned to use these holes to make connections like the ones on a coffee machine water reservoir.

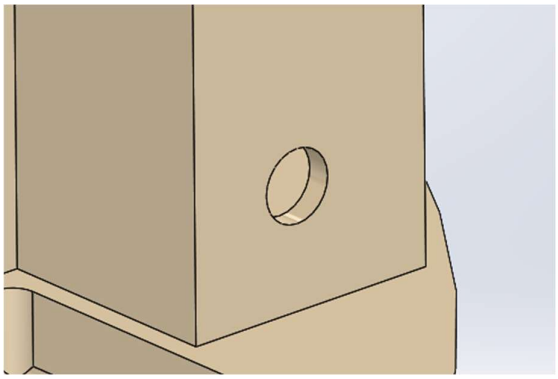


Figure 34. Holes in Reservoir. (own author).

- **Ribs.** Provide weight reduction and less material usage.

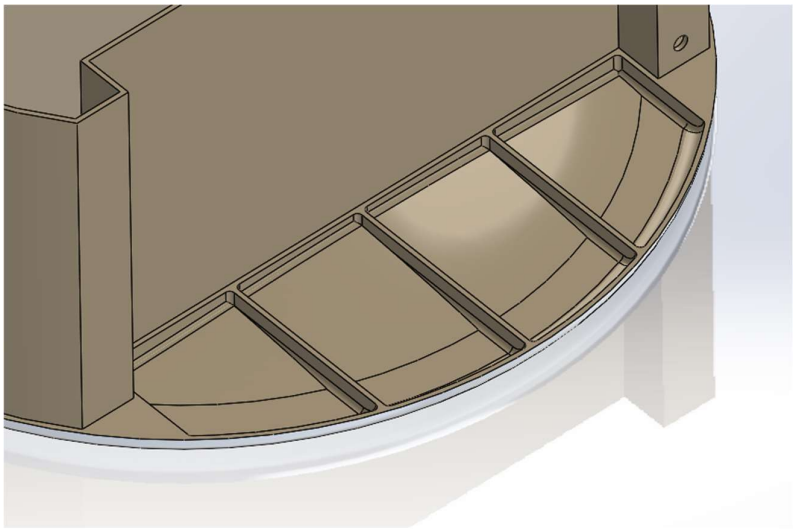


Figure 35. Weight Reduction Ribs. (own author).

Water Pumps

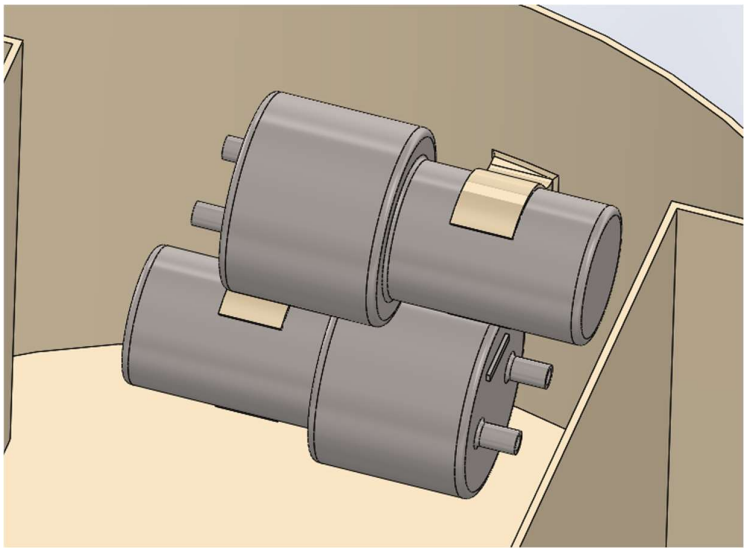


Figure 36. Water Pumps in Device. (own author).

Inside the machine, there are two diaphragm pumps. The first one, on the top, takes the clean water from the left-hand side reservoir and pumps it into the hand box where the scrubbers are placed.

The second pump, on the bottom, takes the dirty water from the bottom of the hand box and pumps it into the dirty water tank.

Figure 37. Tubing of Water Pumps. (own author).

The pumps are connected to the other components via silicone tubing, which is flexible and easy to work with.

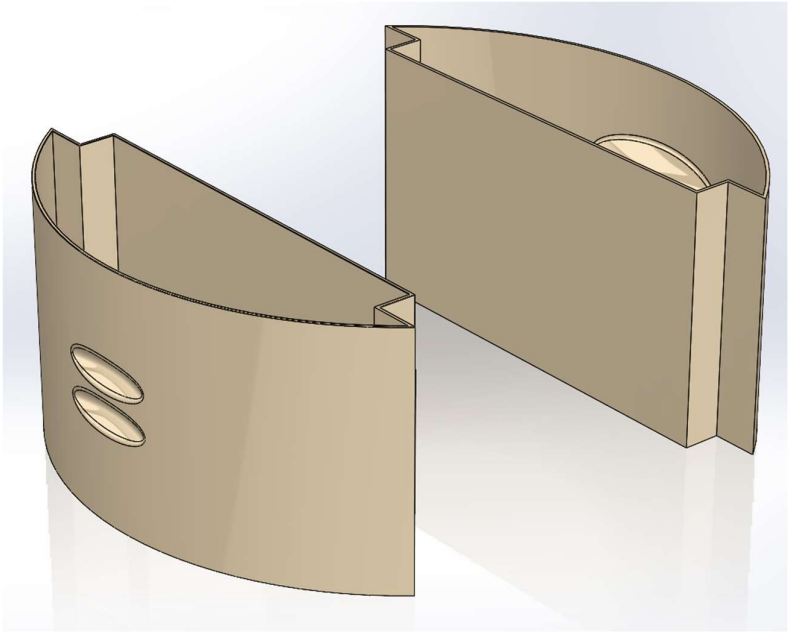


Figure 38. Water Reservoirs. (own author).

These are placed on the left and right sides of the machine and are used to store clean and dirty water. Including the following features:

- **Bottom hole.** This is used for taking clean water out or pumping dirty water in, depending on the reservoir.

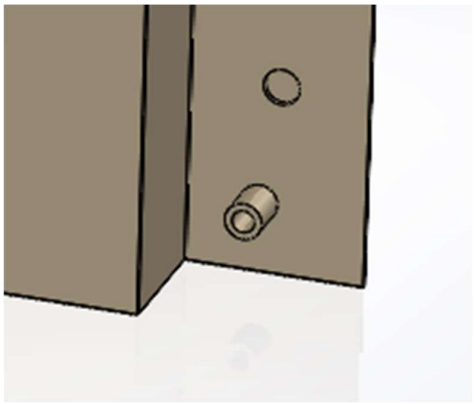


Figure 39. Bottom Hole. (own author).

- **Magnet holes.** These two arrays of holes have the exact size to fit four magnets on each side, which will make the reservoirs stick to the sides of the case.

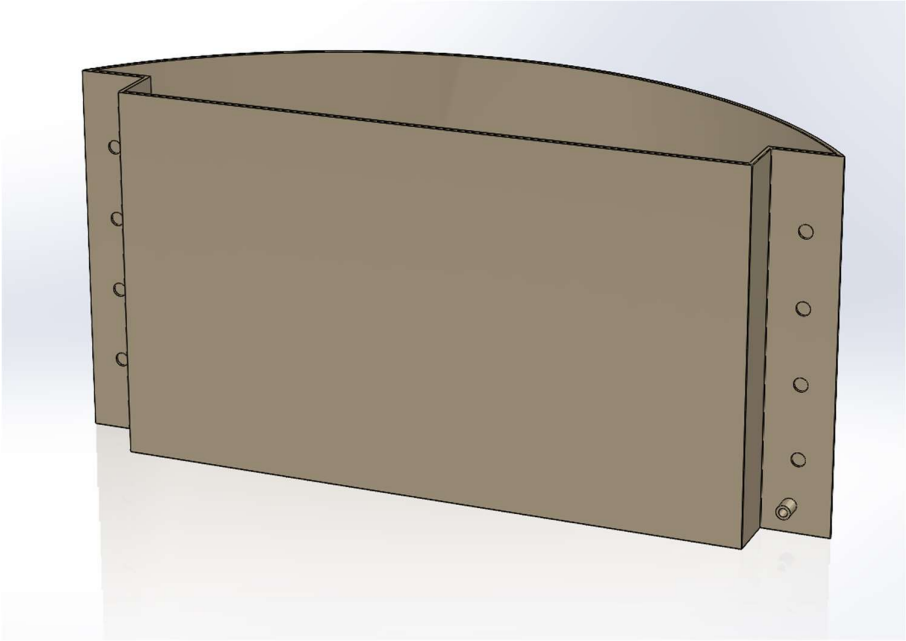


Figure 40. Water Reservoir. (own author).

Reservoir Covers and Caps

To make the reservoirs watertight covers various aspects are needed. With the help of sealing tape, these will fit tightly onto the reservoirs. Additionally, caps for these components have been added to the top, to make the refilling process easier. When closed, the caps will also be sealed. These can be opened and closed easily by the user, as a ball and socket hinge has been incorporated.

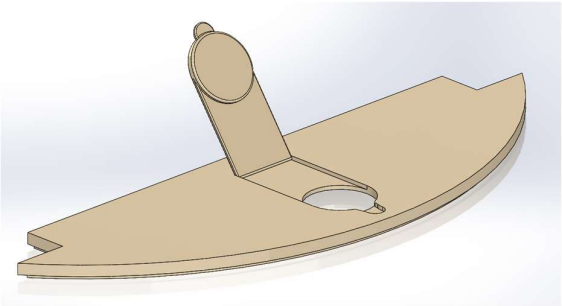


Figure 41. Reservoir Caps. (own author).

Both the covers and the caps are the same on both sides, there is not a left one and a right one. This decision has been made keeping cost-efficiency in mind. Every cover and every cap can be manufactured using the same die, independently from the particular side.

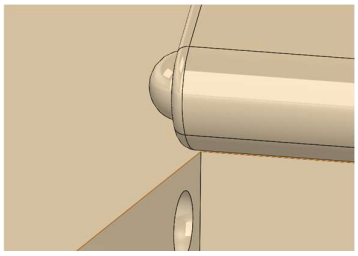


Figure 42. Reservoir Covers. (own author).

Hand Box

Inside the machine, there is an enclosed space in which the scrubbers are located, which is denominated as the "hand box". This enclosure is watertight, protecting the rest of the internal components (I.e. batteries, motors, etc.) from water damage.

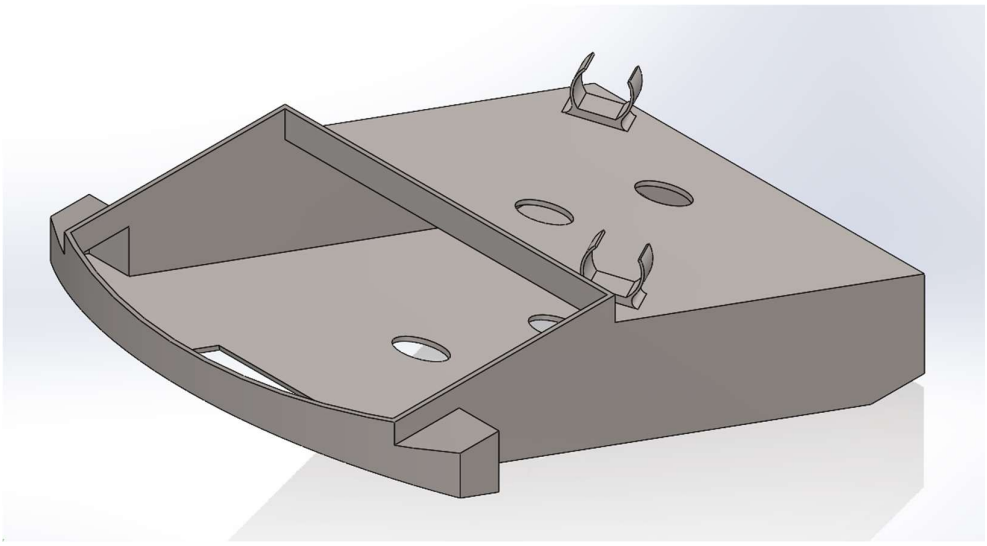


Figure 43. Hand Box. (own author).

It incorporates four clip-like parts (two on the top, two on the bottom) to which the motors of the scrubbers are attached. It also features holes for the scrubber brackets to pass through, as well as a hole for the vertical fan duct.

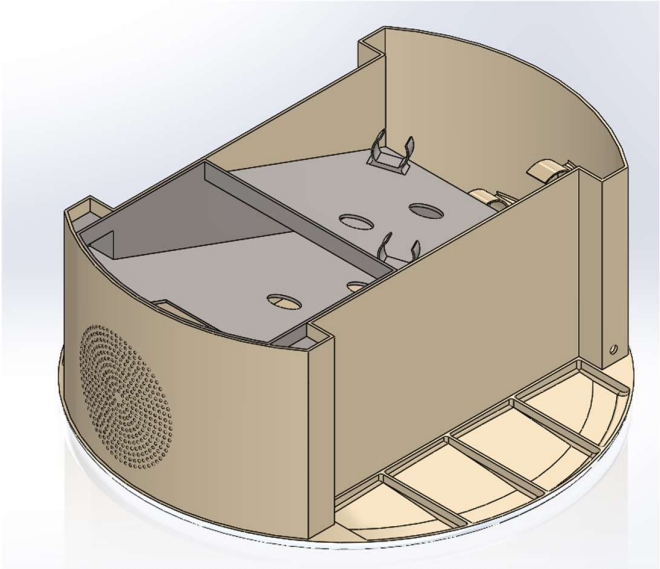


Figure 44. Hand Box in Mainframe. (own author).

Scrubbers

This contraption consists of four main components:

- **Mini DC motor.** Sourced from electric toothbrushes, these small yet powerful motors are capable of delivering enough power to move the gear train.

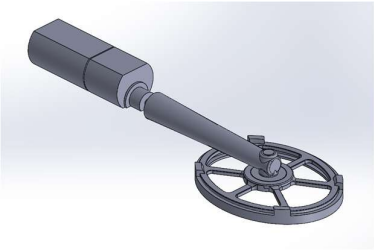


Figure 45. Silicone Holder with Motor. (own author).

- **Gear train.** (Simplified to reduce modelling time) Utilizing a crank-rocker mechanism, this compact gearbox converts the rotational input from the DC motor into an oscillatory movement, thereby moving the toothbrush head.

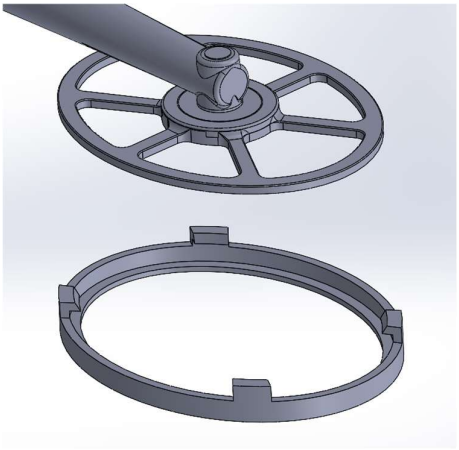


Figure 46. Silicone Holder Exploded. (own author).

- **Toothbrush head.** This part takes the horizontal oscillatory movement input from the gearbox and transmits it vertically to the bracket that holds the scrubber.

- **Scrubber bracket.** The purpose of this part is to attach the silicone pad (scrubber) to the toothbrush head. It is composed of two parts that when clipped together with the scrubber in between, provide a tight hold.

- **Scrubber.** (Not modelled)

  This last part is the one that comes in contact with the user's skin. It is held in place by the bracket, with the bristles facing outwards.

Figure 47. Silicone Pads. (own author).

To dry the user's hands, a drying system has been designed. It is composed of two fans that blow air into two ducts, one positioned vertically and the other horizontally, that guide it to the cutout on the cover in which the user puts its hand. The ducts also make the channel where the air passes through slimmer, which by Boyle's law, makes the air pressure higher and the speed faster.

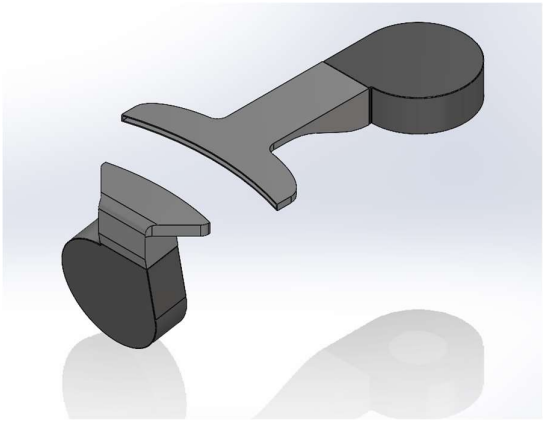


Figure 48. Air blower System. (own author).

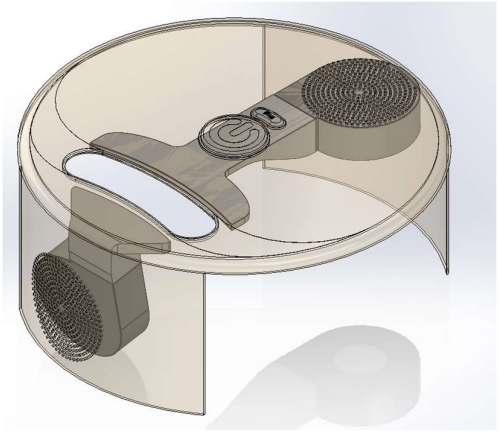


Figure 49. Air Blower System with Mainframe. (own author).

Anti-Slip Pads

These small silicone pieces fit into the 12 sockets at the bottom of the case. These provide stability and grip to the surface where the machine is placed, so it does not move around while being used.

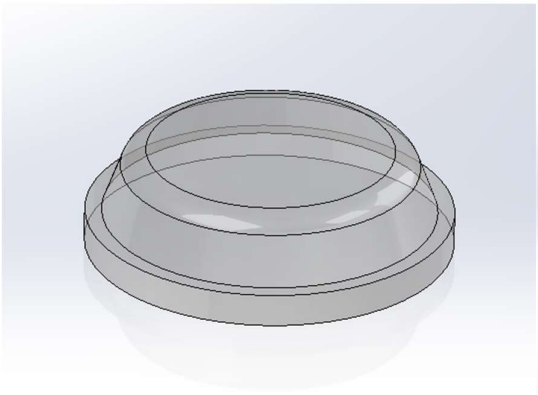


Figure 50. Anti-slip Silicone Pad

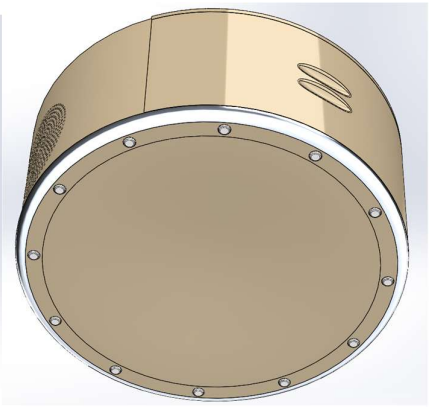


Figure 51. Frame with Silicone Anti-slip Pads

Battery

This single battery provides power for the rest of the components of the machine. It is placed at the bottom of the case.

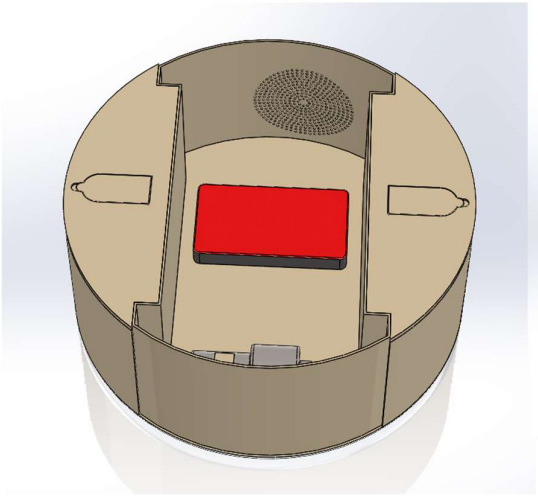


Figure 53. Battery in Mainframe. (own author).

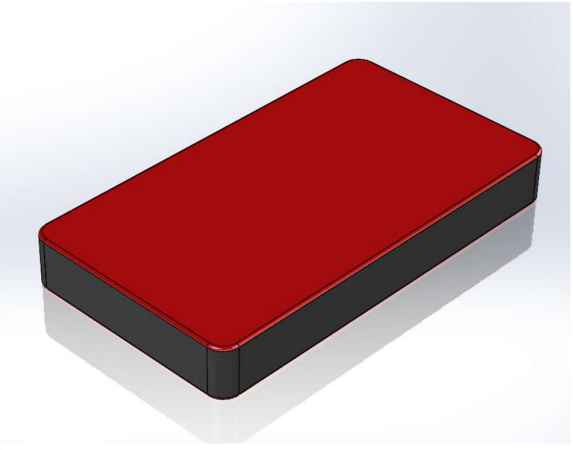


Figure 52. Battery in Mainframe. (own author).

Cover

The final part of the assembly is the cover (see Figure 54), which as its name states, covers all the other components. On the top, it has the main button and the drying on/off button. On the front and the top, it has hole arrays for ventilation purposes. Also, on the top, there is a hole where the user puts the hand in. All over the edge of it, there is a shiny silver-coloured ring, which is only for aesthetic purposes.

Figure 54. The Cover. (own author).

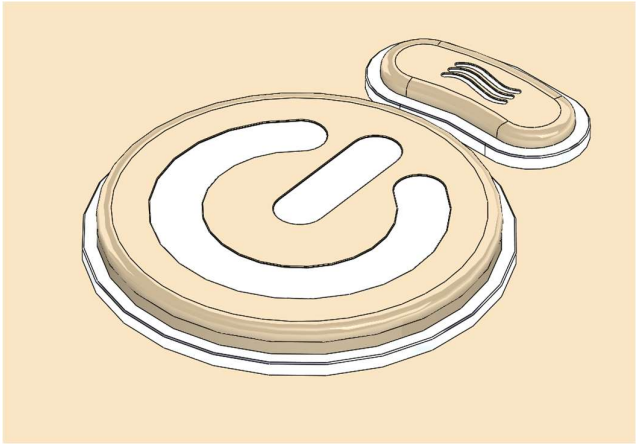


Figure 55. On Button and Drying Button. (own author).

5.2.5 Adjusted Technical Design

Based on the feedback received during the group's midterm presentation and insights gained from the physical 3D printed model regarding product-user interaction, adjustments and modifications have been implemented to enhance the product.

Case

The major change from the model presented during the midterm is in the case. Specifically, the water reservoirs have been redesigned to slide in from the top of the machine instead of the sides. While magnets were initially chosen for fastening, the final design now utilizes the dovetail shape to secure the reservoirs in place.

Figure 56. Exploded view Case. (own author).

Figure 57. Upper view Case. (own author).

Following this modification, the water connections are now positioned at the bottom of the reservoirs, prompting the addition of holes on each side of the case.

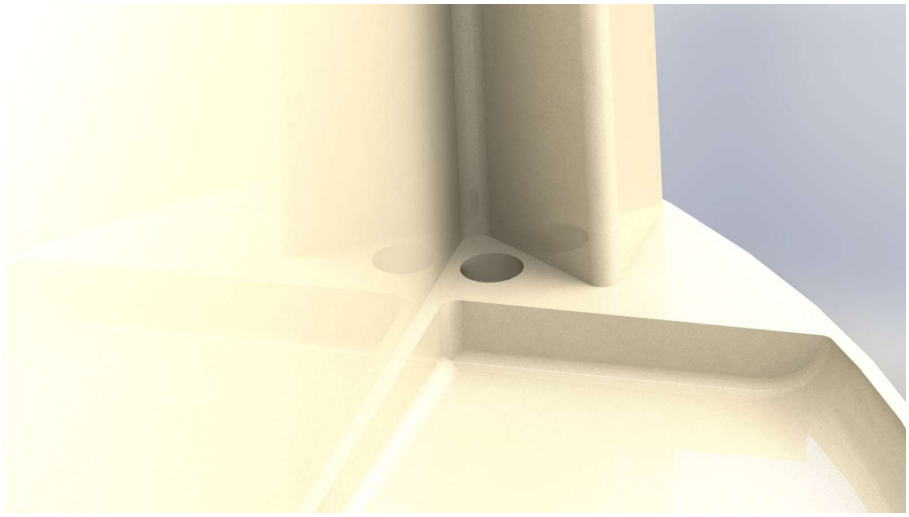


Figure 58. Holes on each side of the case. (own author).

To fasten the cover to the case, four snap-fit clasps have been incorporated on the sides of the machine. These clasps interact with the semi-spherical indentations on the case for secure fastening.

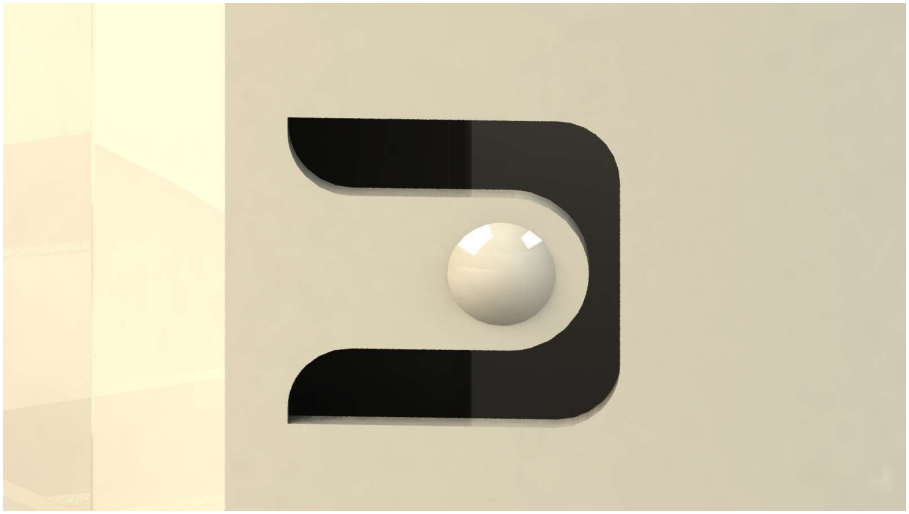


Figure 59. Clips securing case. (own author).

To minimize vibrations from the water pumps, the previous clips securing them in the case have been replaced with rubber fasteners. These rubber fasteners already come

incorporated in the pumps and will be attached with screws to the bottom part of the case, below the hand box, instead of on the side as seen in the earlier design.

Figure 60. Water pump. (own author).

The latest modification to the case, constituting a broader change affecting various components of the machine, involves relocating the hole for the user's hand to the edge rather than the top. Following the 3D printing of the cover and subsequent testing, it was determined that the opening was too narrow. Consequently, a brainstorming session was conducted to redesign this part, leading to the idea of shifting the opening from the top to the edge. This adjustment aims to provide a more comfortable angle for users to place their hands.

Water pumps

The primary modification made to the water pumps is the earlier-mentioned relocation. As illustrated in Picture (), the final placement on paper of these components is depicted. They are arranged in opposing directions to occupy minimal space within the machine, also ensuring they face their respective water reservoirs. In the final prototype, these have been relocated to their original position, on the side of the case.

Water Reservoirs

To fit in the newly implemented dovetail-shaped design, the edges of the reservoirs have been angled inward. This adjustment facilitates their smooth insertion into the slots in the case. Additionally, a small chamfer has been incorporated at the bottom of the reservoirs to ensure easy sliding. The magnet holes have been eliminated, as there are no magnets in the final design. (render water tanks)

A new connection method has been implemented for the water reservoirs. It behaves the same way as some water reservoirs in coffee machines do, using a valve that permits water flow only when the reservoir is placed correctly. The team has bought the necessary parts to implement

Figure 61. Water reservoir with same functioning principle. (own author).

Figure 62. Water valve parts. (own author).

After 3D printing the design of the case shown in the midterm, the project group noticed that the slot was too small to fit a hand in the device (see Figure 72). To debate a solution for this issue a brainstorming session was conducted, in which some ideas were proposed.

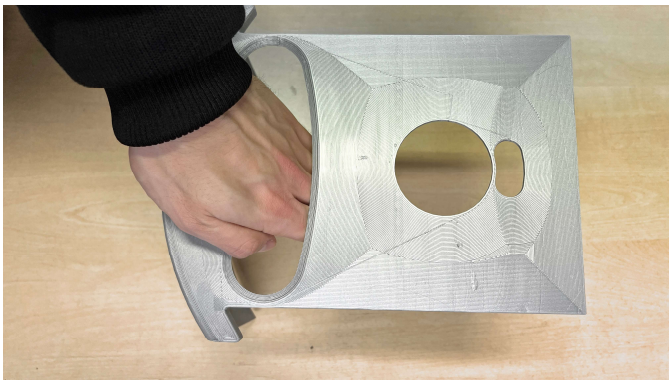


Figure 63. Fitting hand with an angle. (own author).

The first solution would be to create a curved surface on the upper side of the machine, to provide a more comfortable angle for the user's hand to go in (see blue sketch). However, this would not solve the problem, as it would still not provide the optimal entrance angle (shown in the red sketch). would most likely not have been solved at this point. That is why the project group considered creating a hole at the edge of the machine (see orange sketch). This could lead to putting the hand at the right angle, solving the problem.

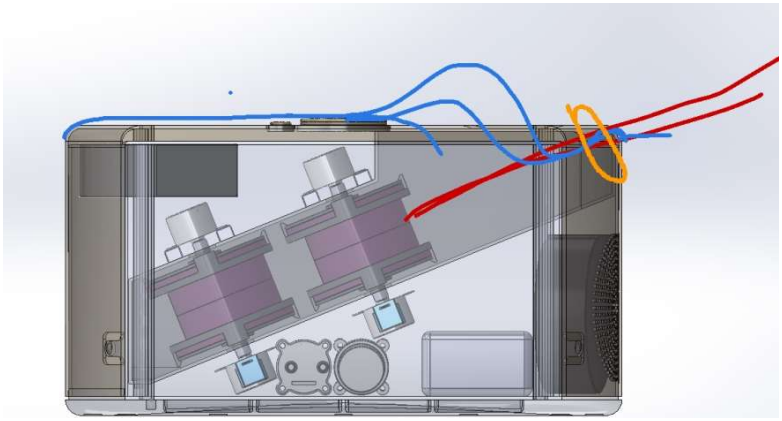


Figure 64. Possible Solutions Hole. (own author).

This adjustment would initially look as shown in Figures 64 and 65.

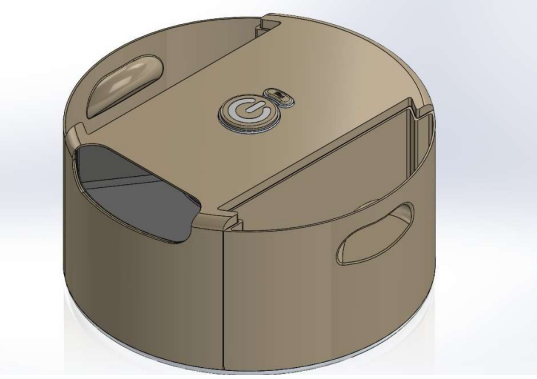


Figure 65. Picture of the adjusted model. (own author).

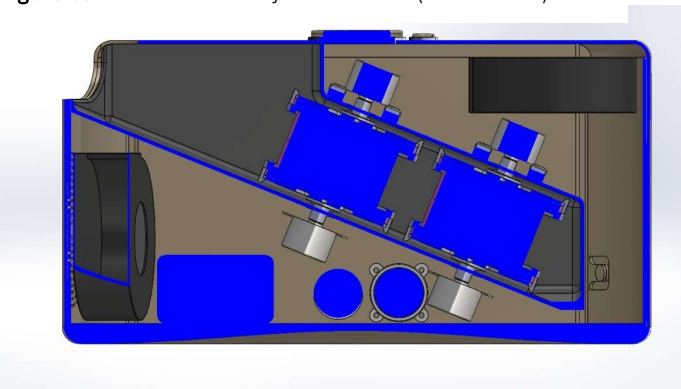


Figure 66. Cross Section adjusted model. (own author).

To adapt to this iteration of the design, some parts had to be redesigned. These include the case, the cover, the hand box and the air ducts.

Hand box

The hand box remains almost the same as in the midterm design, with only some minor modifications. The hole for the hand has been adapted to the new design, the holes have been given a raise, and a slot to pass cables from the top motors to the electronic boards has been put on the left side.

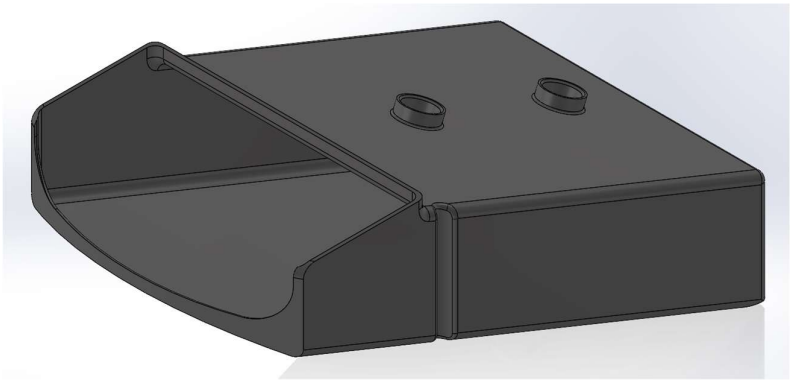


Figure 67. The hand box frame. (own author).

Motors

The group decided that instead of using a mechanism with gears and rods, among other mechanical parts, it would be more convenient to directly drive each scrubber with one motor. This change entails a rise in the height of the machine, which is not what the client desired, but it is understood that for the prototype this liberty can be taken. The machine can be lower in height when more work is performed in the mechanical area and the volume occupied by the motors is reduced.

Watertightness

To prevent any leakage from occurring, waterproofing solutions have been thought about for every part containing water. The first of these are the water reservoirs. In the first place, it was proposed to use a waterproofing spray for PCBs and other electronic components.

This idea was later discarded for the final product, as research showed that the chemicals used in the spray could be toxic to the skin, but it was used for the prototype.

Epoxy resin was used to seal all silicone tube connections in the prototype, as it is more convenient to work with in tight spaces when compared to a hot glue gun, which was the second option.

For the holes that connect the motors and the scrubbers through the hand box, rod seals were intended to be used. These pieces were bought, but the team was not able to mount them in the prototype due to the lack of time.

Air ducts

These two pieces conduct the airflow from the air blowers to the hole for the hand. With the redesign of the position of the hole, the previous design of these components was obsolete, and they had to be modified.

The newer version of the ducts adapts its shape to the rest of the components inside the machine, like the motors and the buttons, while maintaining a satisfactory air distribution. This statement is proven by CFD (Computational Fluid Dynamics) simulations.

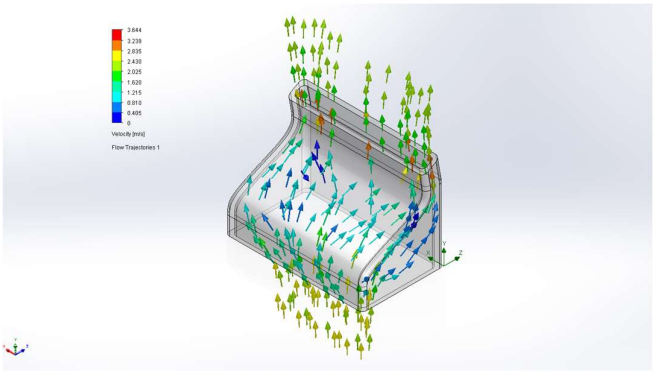


Figure 68. Airflow Lower Air Channel. (own author).

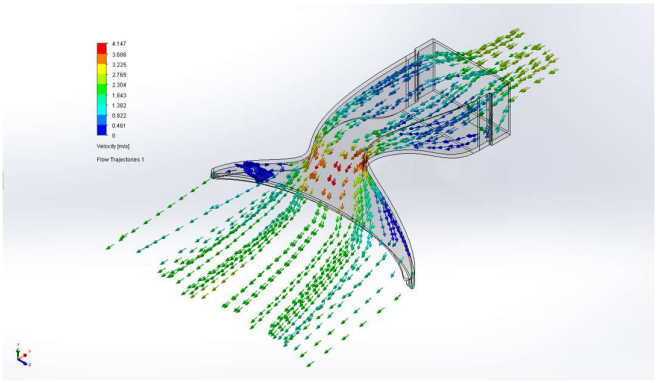


Figure 69. Airflow Upper-Air Channel. (own author).

5.2.6 Electrical System

The electronic system is designed for an automated hand hygiene process, incorporating various components such as a water pump, motor, and fan. The system utilizes a microcontroller to control the sequence of actions, including the application of liquid, hand scrubbing, rinsing, and drying. Specifically, an Arduino microcontroller is employed to coordinate these actions and ensure proper timing between the activation of the water pump, motor, and fan.

The system initiates with the application of liquid to the hands, simulated by activating the water pump. The corresponding code (see 4.2.8 Program code) controls the water pump's operation for a specified duration before deactivating it to halt the liquid supply.

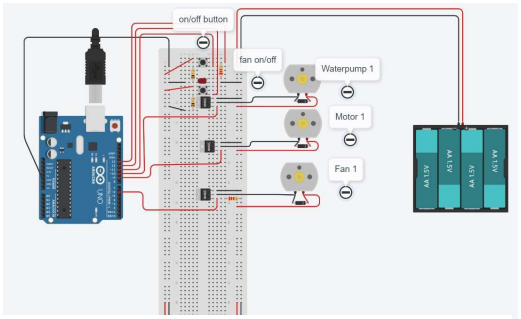


Figure 70 Electrical system. (own author).

Following the liquid application, hand scrubbing is simulated by activating the motor. The associated code governs the motor's operation for a specific duration before deactivating it.

Post-scrubbing, the rinsing process is initiated by reactivating the water pump. The code ensures that the rinsing occurs for a designated period before deactivating the water pump.

Drying of the hands is simulated by activating a fan. Similar to the other components, the code regulates the fan's operation for a specified duration before deactivating it to complete the drying process.

Integral to the system is the implementation of push buttons, including "button_on_off" and "button_fan", allowing for manual control. The code is configured to ensure that the system performs actions only when "button_on_off" is pressed. Additionally, functionality is incorporated to turn off the fan when "button_fan" is pressed.

To prevent immediate responses upon startup, debouncing techniques are employed, preventing undesired fluctuations in button status and ensuring stable system operation.

A significant addition to the code is the system's capability to remember the fan status. This means that once the fan is turned off using "button_fan," this status is retained for subsequent cycles, even after the system has been stopped and restarted.

Throughout the implementation, challenges and issues, such as debouncing errors and unexpected button behaviour, emerged. These were identified and addressed through code adjustments and the incorporation of appropriate control mechanisms.

Collectively, this forms a robust foundation for an automated hand hygiene system. The electronic schema and associated code enable the controlled and orchestrated activation of various components, resulting in an effective handwashing procedure.

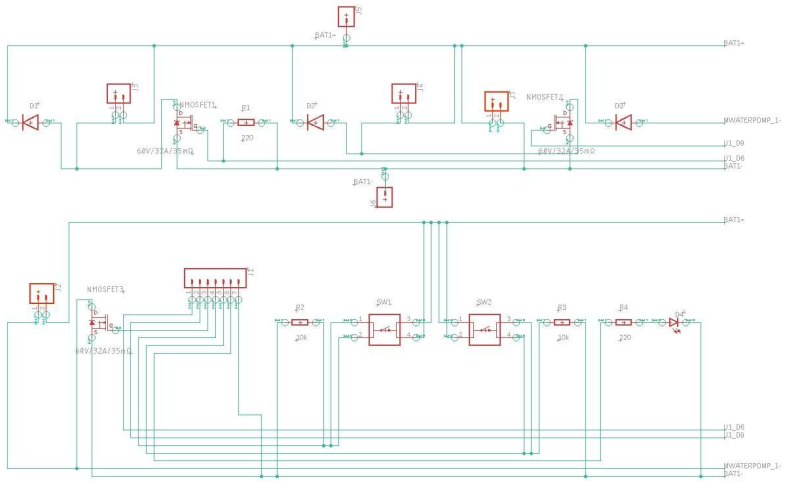


Figure 71. Electrical Scheme. (own author).

5.2.7 Program Code

In the code used for this project, there has been a set of instructions written in a language that computers understand. The purpose of these instructions is to control various electronic components, creating a system with specific functionalities.

The code begins by defining and assigning values to different pins that connect to physical components like buttons, LEDs, motors, and a fan. These pins act as the communication channels between the code and the hardware.

The setup function initializes the system, specifying the input and output characteristics of each pin. It also sets up communication through the serial interface for potential debugging or monitoring.

Following the setup, there are two custom functions: setStep and motorControl. The setStep function is responsible for activating specific combinations of pins to control a stepper motor, determining its movement. The motorControl function utilizes setStep to run the stepper motor in a predefined sequence for a set period.

The main loop of the code continuously monitors the state of two buttons: one for turning the system on and off, and the other for controlling the fan. It reads the digital input from these buttons and checks for changes, applying a debounce mechanism to avoid false triggers due to electrical noise.

When the system is turned on (as indicated by the state of the ON/OFF button), a series of actions are executed. First, a water pump is activated for a certain amount of seconds (HIGH state), then the stepper motor goes through a specific movement sequence for a duration of a certain amount of seconds. Afterward, the water pump is activated again for another certain amount of seconds. Finally, the code checks the status of the fan button and turns the fan on or off accordingly.

The entire process is monitored and reported through the serial interface, providing information about the state of the ON/OFF and FAN buttons. In essence, this code creates a controlled system with specific actions triggered by button inputs. The combination of hardware components and code execution results in a functioning mechanism.

5.2.8 Materials Purchased for Development

Within the scope of the project, a total of 23 distinct items have been procured, each fulfilling a specific and integral role within the project's framework. Notably, among these purchases are three diverse water pumps, identified as components 3, 4, and 5, acquired for the exact purpose of subjecting these to thorough evaluation to determine the most effective solution for the application.

The combined financial commitment for this thorough inventory currently stands at €555.70. It is pertinent to emphasize that this financial investment reflects a discerning selection process informed by thorough research. Given the current stage of investigation, it is anticipated that minimal supplementation of additional components will be needed.

Table 14. Materials Purchased for Development. (own author).

Part #	Description	Qty	Unit C	Total U	Delivery Cost	Total Cost	Supplier	Origin	Due Date	Link
1	Electric Toothbrush	2	€ 23.96	€ 47.92		€ 47.92	Amazon	Germany	25/09/2023	X
2	Air Blower	2	€ 13.14	€ 26.28		€ 26.28	Amazon	Germany	Unkown	X
3	Waterpump (Peristaltic)	2	€ 16.80	€ 33.60		€ 33.60	Amazon	Germany	25/09/2023	X
4	Waterpump (Fish Tank)	1	€ 9.90	€ 9.90		€ 9.90	Amazon	Germany	27/09/2023	X
5	Waterpump (Diaphragm)	2	€ 11.00	€ 22.00		€ 22.00	Amazon	Germany	25/09/2023	X
6	Connectors	1	€ 18.99	€ 18.99		€ 18.99	Amazon	Germany	22/09/2023	X
7	Silicon Pads	1	€ 8.95	€ 8.95		€ 8.95	Amazon	Germany	25/09/2023	X
8	Castile soap	1	€ 9.99	€ 9.99		€ 9.99	Amazon	Germany	25/09/2023	X
9	Water Tank	1	€ 12.60	€ 12.60		€ 12.60	Amazon	Germany	10/10/2023	X
10	Door Damper	1	€ 15.99	€ 15.99		€ 15.99	Amazon	Germany	10/10/2023	X
11	Silicone Body Brush	1	€ 11.37	€ 11.37		€ 11.37	Amazon	Germany	11/10/2023	X
12	Cloudberry	1	€ 44.90	€ 44.90		€ 44.90	Motonet	Vasa	01/11/2023	
13	USB cable	1	€ 1.95	€ 1.95		€ 1.95	Starelec	Vasa	24/10/2023	X
14	Urethane spray	1	€ 20.08	€ 20.08		€ 20.08	Starelec	Vasa	24/10/2023	X
15	Magnets	1	€ 3.50	€ 3.50		€ 3.50	Starelec	Vasa	24/10/2023	X
16	Willkem Facial Clean	2	€ 2.90	€ 5.80		€ 5.80	Minimani	Vasa	18/09/2023	X
17	Kuorintatyyny	2	€ 4.50	€ 9.00		€ 9.00	Minimani	Vasa	18/09/2023	X
18	Smile lite SÄHKÖHAMM	1	€ 22.95	€ 22.95		€ 22.95	Minimani	Vasa	18/09/2023	X
19	Letku Spray Tuotteis	2	€ 9.95	€ 19.90		€ 19.90	Minimani	Vasa	18/09/2023	X
20	Vitality Pro White S	1	€ 34.95	€ 34.95		€ 34.95	Minimani	Vasa	20/09/2023	X
21	Water Tank	1	€ 10.59	€ 10.59		€ 10.59	Amazon	Germany	16/10/2023	X
22	Door Damper	1	€ 13.44	€ 13.44		€ 13.44	Amazon	Germany	16/10/2023	X
23	Silicon Body Brush (hairy)	2	€ 11.37	€ 22.74		€ 11.37	Amazon	Germany	16/10/2023	X
24	Arduino Uno	1	€ 34.76	€ 34.76		€ 34.76	Starelec	Vasa	02/11/2023	
25	koekytkentäalusta RoHS	1	€ 3.53	€ 3.53		€ 3.53	Starelec	Vasa	02/11/2023	
26	kytkentäjohdinsarja 65kpl/ppk RoHS	1	€ 3.53	€ 3.53		€ 3.53	Starelec	Vasa	02/11/2023	
27	kykentäjohdinsarja 10 kpl/pkk RoHS	1	€ 1.73	€ 1.73		€ 1.73	Starelec	Vasa	02/11/2023	
28	Shaft Seals	5	€ 1.64	€ 8.20		€ 8.20	Amazon	Germany	28/11/2023	X
29	Silicone Anti Slip	1	€ 4.99	€ 4.99		€ 4.99	Amazon	Germany	21/11/2023	X
30	Silicone Sheet	1	€ 12.99	€ 12.99		€ 12.99	Amazon	Germany	21/11/2023	X
31	Belt	1	€ 9.99	€ 9.99		€ 9.99	Amazon	Germany	20/11/2023	X
32	Water Lock (First Order)	1	€ 5.94	€ 5.94		€ 5.94	Amazon	Germany	21/11/2023	X
33	Water Lock (Second Order)	1	€ 8.99	€ 8.99		€ 8.99	Amazon	Germany	01/12/2023	X
34	Waterproof Tape	1	€ 18.85	€ 18.85		€ 18.85	Amazon	Germany	29/11/2023	X
35	Stepper Motors	1	€ 16.19	€ 16.19		€ 16.19	Amazon	Germany		X
36	Coupler	1	€ 9.99	€ 9.99		€ 9.99	Amazon	Germany		X

(own author).

6 Create & Test Prototype

The chapter 'Create & Test Prototype' encompasses crucial subchapters: 'Plan of Approach Creating & Testing,' 'Mechanical System,' 'Electronical System,' 'Assembling,' and 'Quality Control and Testing.' This chapter explores the systematic creation, integration, and assessment of mechanical and electronic systems, assembly processes, and quality control measures for prototypes.

6.1 Plan of Approach Creating & Testing

In the final phase of the project, where the customer's needs and the design have already been determined, the primary focus shifts towards manufacturing, assembling, and testing the Hand Sanitizer device.

Manufacturing

The plan to create most of the parts designed by the team is using 3D printing. This manufacturing method is fast, inexpensive, and easy to master as opposed to other more conventional plastic fabrication methods, like injection moulding. The materials, as well as the machines, are already at Technobothnia and available to use.

In addition, the electrical system needs to be created to let the prototype function properly. With this in mind, the project group needs to construct a PCB which has the right functions. As a result of this, the prototype will obtain an organized electrical structure that will contribute a crucial part to the prototype.

Assembling

With the frame components ready, the next stage will encompass the assembly of electronic and mechanical parts. Electronic components, including wires, pumps, motors, and mechanical parts, will be integrated. The frames will also be assembled, and for the reservoir, magnets will be utilized. The assembly process will employ suitable adhesives to join frame components, with a particular emphasis on providing a working system.

Quality Control and Testing

The assembled device will undergo the rigorous quality control checks stated in point 3.7 of this document. The team will conduct this set of tests internally. Calibration of wires,

pumps, motors and mechanical parts will be carried out to guarantee proper functionality. The results of this testing will help the team identify and rectify any manufacturing or assembly issues that may arise. Also, a sustainable assessment will be part of this phase to ensure compliance with EU Regulations.

User Testing

Following the internal quality control and testing, the team will move on to user testing. This phase will involve collaborating with external groups of test subjects.

The team has been in touch with teachers from the makeup field to propose their students to test the prototype. Their feedback will be essential in assessing the device's ease of use, ergonomics, and overall performance when the prototype is ready.

The team has also contacted a physical cosmetics store at Vaasa. It was proposed to bring the prototype to the shop for clients to test, but no response has been received from the store manager.

Feedback Integration and Refinement

Based on the feedback gathered from the project group, any necessary adjustments or refinements will be made. This iterative process aims to ensure that the device meets the highest standards of functionality and user-friendliness.

Documentation and Reporting

Throughout this phase, meticulous records will be maintained to document all manufacturing, assembly, and testing activities. The Reporting will be done through the last stages, so the fine-tuning can be done at last. These records will be crucial in the preparation of a comprehensive report that summarizes the entire project and outlines the successful completion of the Hand Sanitizer device, serving the needs of makeup students effectively.

6.2 Manufacturing

The 'Manufacturing' subchapter explores crucial components like the frame,' 'Mechanical System,' and 'Electronical System.' 'Frame' forms the structural base, 'Mechanical System' comprises moving parts, and 'Electronical System' involves electronic components. This segment aims to illustrate the interplay between these elements in the manufacturing process, offering insights into their roles within the product's creation.

6.2.1 Frame

About the 3D printing process

In Technobothnia's 3D printing laboratory, various machines with a wide range of specifications are available for use. Key differentiators among these machines include the size of the print bed, determining the maximum dimensions of producible parts, and the nozzle diameter, determining the upper limits of layer height values.

Concerning the fabrication of components like water reservoirs, the hand box, the case, and the cover, each characterized by unique shapes and sizes, the selection of an appropriate machine aligning with specific requirements becomes crucial.

Printing the water reservoirs

Initially, the intention was to utilize the Ultimaker S5, as Ultimaker is renowned for its sophistication and superior print quality. The S5 is the biggest printer available from this brand. However, a limitation arose as the print bed of the Ultimaker S5 proved inadequate (not large enough in the XY plane) to print larger pieces such as the water reservoirs, the cover and the case. Consequently, the Creality CR-10 S5 emerged as a choice, as the size of the print bed was significantly larger and provided enough space to print the parts. Regrettably, complications arose during the printing process, resulting in a failed print, as depicted in Figure 57.

Subsequently, the causative factor behind the printing failure was investigated. The identified issue was a defect denominated as a layer shift. Layer shifting in 3D printing refers to a situation where the layers of a printed object are not properly aligned, causing a visible misalignment or offset in the printed layers. This misalignment can occur in one or

more axis and typically results in a skewed or distorted appearance of the printed object. (Simplify3D, n.d.).

The cause of layer shifting can vary and may include factors such as mechanical issues, electrical problems, or issues with the 3D printer's firmware. One common scenario involves the stepper motor, which is responsible for moving the print head in precise increments. If the motor encounters resistance, skips steps, or encounters any unexpected hindrance, it can lead to a misalignment of subsequent layers. It is believed that one of these is the errors that made the print fail.

An illustrative example of this defect is evident in Figures 60, 61 and 62. Despite exhaustive efforts, the issue was unable to be solved, necessitating a shift to an alternative machine to complete the fabrication.

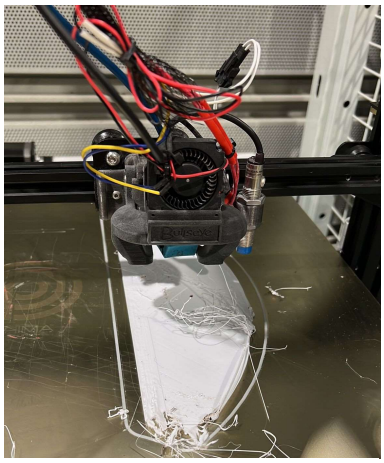


Figure 75. Issues with printing using Creality 10 S5. (own author).

Figure 74. Layer Shift. (own author).

Figure 73. Failure in printing cause by the Layer Shift. (own author).

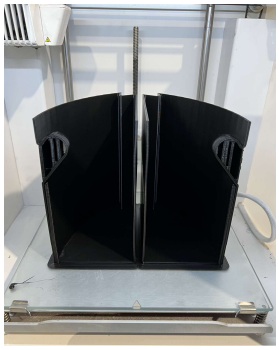


Figure 72. Reservoir in the printer. (own author).

The alternative printer choice was the Ultimaker S3. This machine had a smaller print bed surface. However, the print quality was as satisfactory as in the S5. To adapt to this smaller print bed size, the reservoir would be printed in two pieces (see Figure 60), and then glued using epoxy resin. The final product was a water reservoir with the desired quality (see Figure 61).

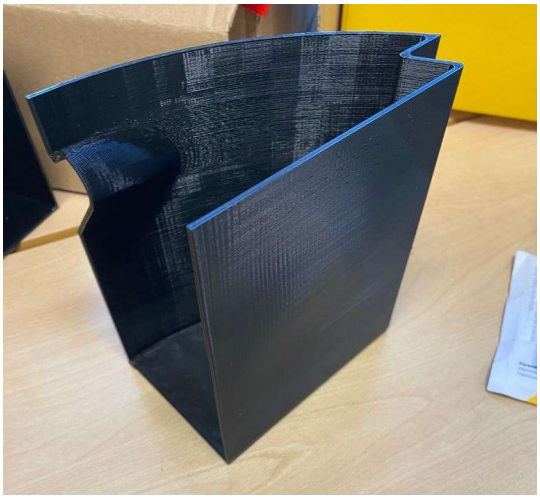


Figure 76. Cross Section Reservoir. (own author).

The handle on this part is specially adapted to the 3D printing process, as it is inclined 50 degrees to the ground to eliminate overhangs and thus the need for support. 3D printers cannot print on air, at least part of a lower layer must be underneath the newly printed material, and that is what this design accomplishes.

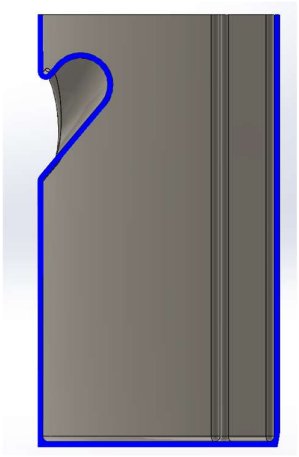


Figure 77. Cross section with visible handle. (own author).

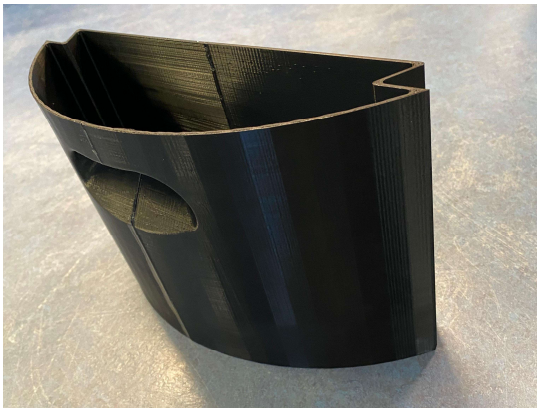


Figure 78. Glued Reservoir. (own author).

Printing *the case*

The most voluptuous component of the prototype, the case, had to be divided into four separate pieces to accommodate the size limitations of the printers. While glueing the water reservoirs, the concept of incorporating a shape to securely connect the different parts emerged. Following some research, it was determined that dovetail shapes are commonly employed for such applications. Consequently, these features were integrated into the design and slicing of the case. Additionally, a small gap of 0.4mm was introduced between each piece to account for the material's inevitable expansion during the printing process.

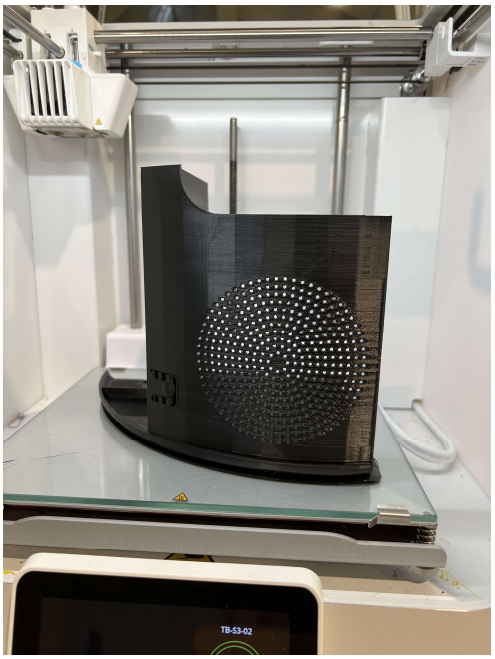


Figure 79. The first quarter of the case is in the printer. (own author).

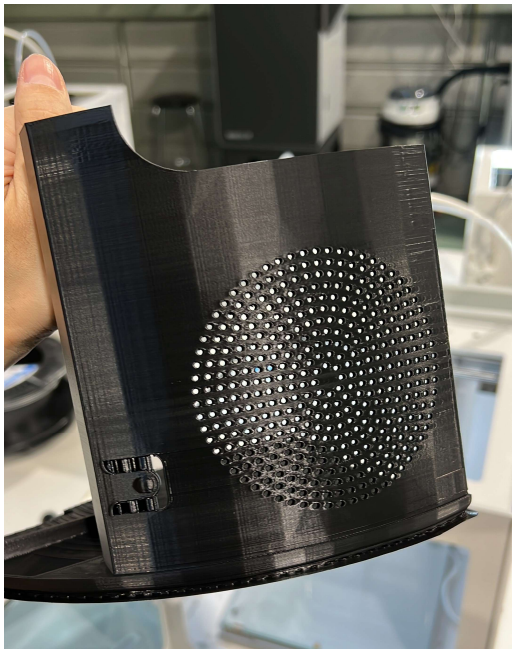


Figure 80. Holes in the first quarter. (own author).

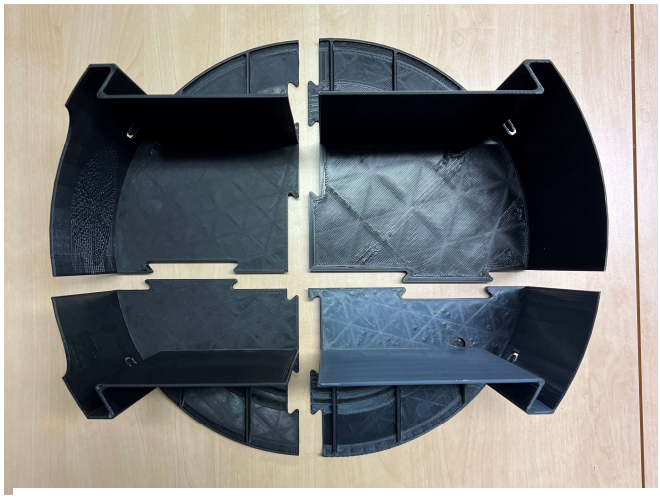


Figure 81. Case before Assembly. (own author).

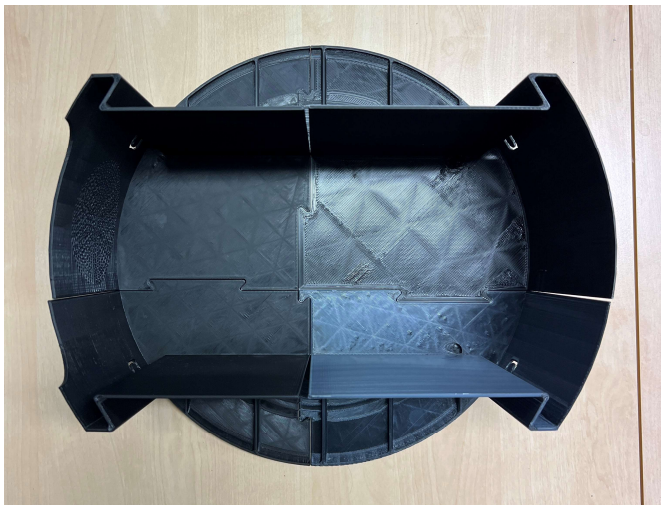


Figure 82. Case after Assembly. (own author).

Figure 83. Case before assembly Detail of Dovetail. (own author).

Printing the cover

The cover needed to be divided into two pieces. The initial iteration (printed in grey) retained the original hole for the hand. Subsequent testing revealed that the hole was too narrow, prompting adjustments to relocate it to the edge of the machine. Printing the second version highlighted that the hole was still too small, leading to the creation of a third and final version.

The decision to split the cover into two parts proved advantageous in terms of time and material efficiency. Only half of the part containing the hand hole needed to be printed for each modification, facilitating a more resource-effective approach.

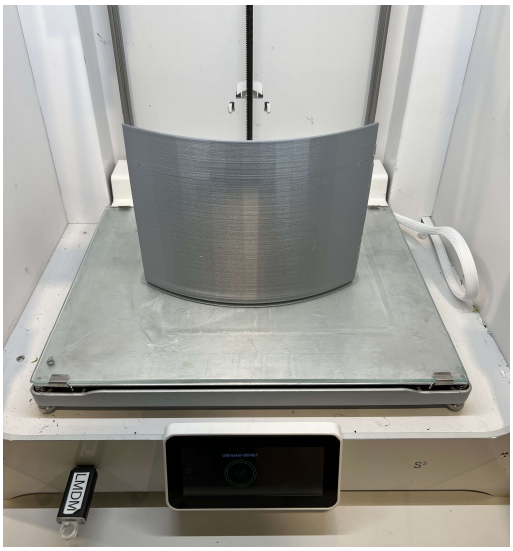


Figure 84. Printing the Cover. (own author).

Printing the handbox

To print the hand box the team used the Ultimaker S5, as it had a printing volume big enough to print the part in one piece. To reduce the amount of support needed to the minimum, the part was positioned at a highly steep angle. This results in a cleaner part with less amount of post-processing. Additionally, *tree supports* were used. These kinds of supports use less amount of material when compared to conventional supports, and are faster to print as well as easier to remove.

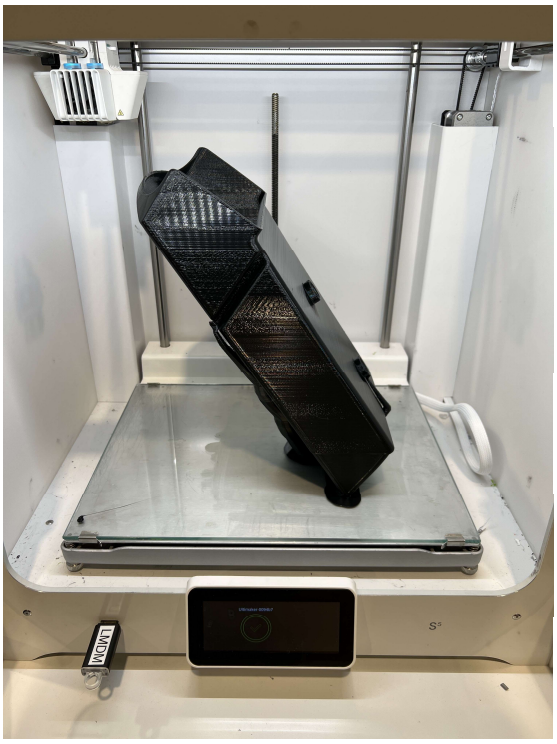


Figure 85. Printing the Hand box. (own author).

Figure 86. Support of the Hand box. (own author).

Printing other parts

Other smaller parts were printed in one piece, as the printers were large enough to fit them. These include the reservoir covers, the scrubber holders and a miniature model of the machine which was given to the clients in one of the meetings.

These smaller prints did not cause any major issues. The only error occurred while printing one of the covers of the water reservoir, but it was solved easily by printing it flat.

Figure 87. Failed Printing of Cover of Water Reservoir. (own author).

6.2.2 Mechanical System

As stated earlier in point 5.2.5, the group decided that instead of using a mechanism with gears and rods, among other mechanical parts, it would be more convenient to directly drive each scrubber with one motor. To assemble the four motors to the scrubbers inside the hand box different pieces were used.

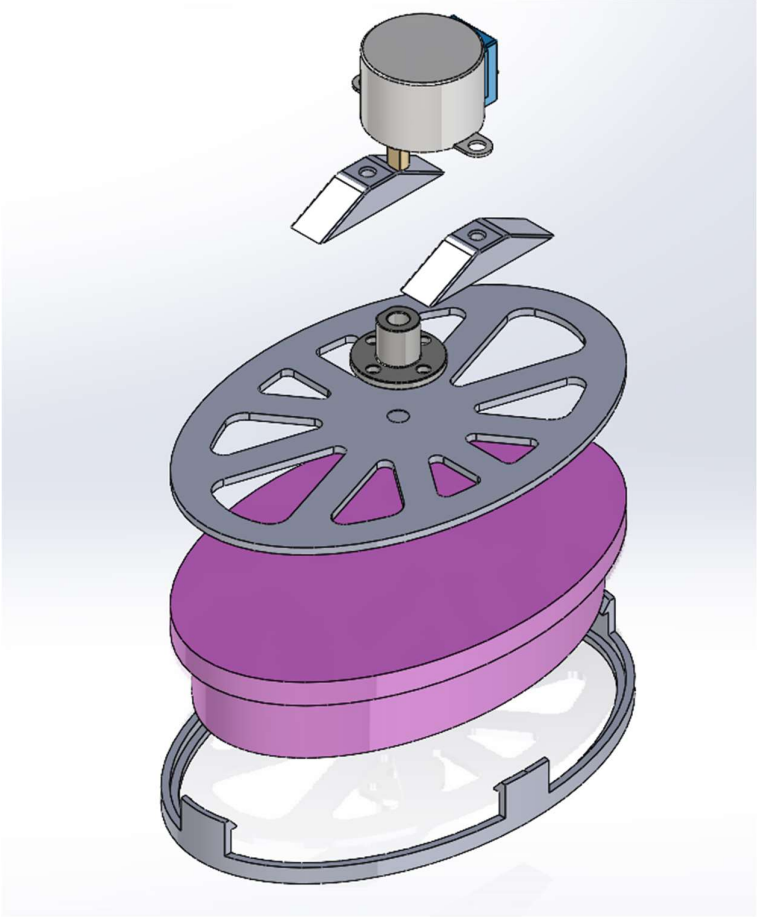


Figure 88. Exploded view Mechanical System. (own author).

Supports

Two of these small 3D-printed pieces are required for each motor, one for each side. They serve to provide the necessary elevation in height relative to the hand box, ensuring that the remaining components align at the appropriate height.

Flange coupler

To transfer the motor's movement to the scrubber holder, a flange coupler is essential. This component features an inner diameter matching the external diameter of the shaft, secured in place with a small hexagonal screw. On the opposite side, four holes allow for the attachment to the scrubber holder through screwing.

Scrubber holder

Composed of two 3D printed pieces, these parts are the ones in charge of tightly subjecting the silicone scrubbers.

Future design suggestion

In further versions of the design, a system using gears, shafts, and other components might lead to a machine shorter in height. With more work in this area, the volume occupied by the motors can be optimized. The sketch in Figure 89 suggests a basic way of achieving this.

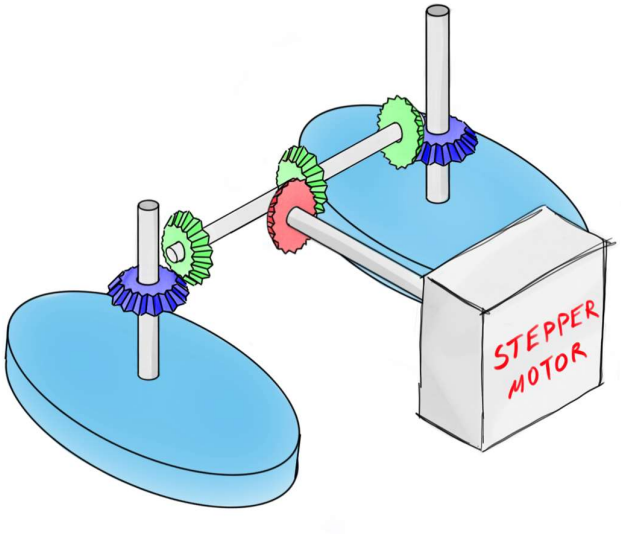


Figure 89 Stepper motor idea

6.2.3 Electronical System

In the pursuit of optimizing the electronic component integration within the system, the objective was to eliminate the need for a breadboard directly within the machine. To achieve this, a dedicated printed circuit board (PCB) was designed and developed. The process involved translating the electronic schema into a format compatible with Eagle, a widely used PCB design software. The intricacies of the system's electronic architecture were carefully considered to ensure seamless integration and functionality.

The decision to forego the traditional breadboard within the machine stemmed from a desire for a more compact and streamlined design. A custom PCB not only serves this purpose but also contributes to enhanced reliability and ease of assembly. With the groundwork laid in the electronic schema, the subsequent step involved meticulous placement of components within Eagle to reflect a logical and efficient arrangement.

In the schematic-to-PCB transition, each component played a crucial role, mirroring the real-world functionalities of the water pump, motor, fan, and associated buttons. The microcontroller, an Arduino in this context, emerged as the central orchestrator, governing the sequence of actions. The code

governing the microcontroller was designed to initiate and control specific functions at designated intervals, ensuring a cohesive and synchronized performance.

The water pump, a pivotal component simulating the application of liquid during the hand hygiene process, was allocated a strategic position on the PCB. The corresponding code dictated the pump's activation for a predetermined duration before seamlessly deactivating it to halt the liquid supply, mirroring a real-world handwashing scenario.

Similarly, the motor, representing the hand scrubbing phase, found its place on the PCB with careful consideration of the logical flow of actions. The code associated with the motor ensured its activation for a specific timeframe before deactivating it, simulating the scrubbing process in the hand hygiene sequence.

The integration of a fan component, simulating the drying phase, was also thoughtfully executed on the PCB. The code governing the fan dictated its activation and deactivation at precise intervals, contributing to the realism of the hand hygiene procedure.

Crucial to the system's user interface were the push buttons, including "button_on_off" and "button_fan," strategically positioned for manual control. The code was intricately crafted to respond to the pressing of these buttons, ensuring that the system executed specific actions only when prompted by the user.

Debouncing techniques were implemented to mitigate potential challenges arising from the rapid fluctuation in button statuses during activation. This enhancement added a layer of stability to the system, preventing unintended responses and ensuring a smooth user experience.

The realization of this electronic system extended beyond the virtual realm of Eagle, translating theoretical concepts into a tangible and functional design. The custom PCB, with its optimized arrangement of components, represents a significant milestone in the development of an automated hand hygiene system that seamlessly integrates electronic elements for a comprehensive and effective user experience.

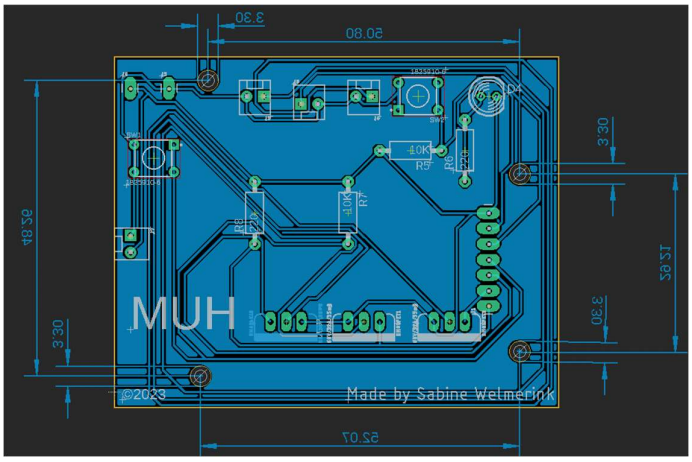


Figure 90. PCB. (own author).

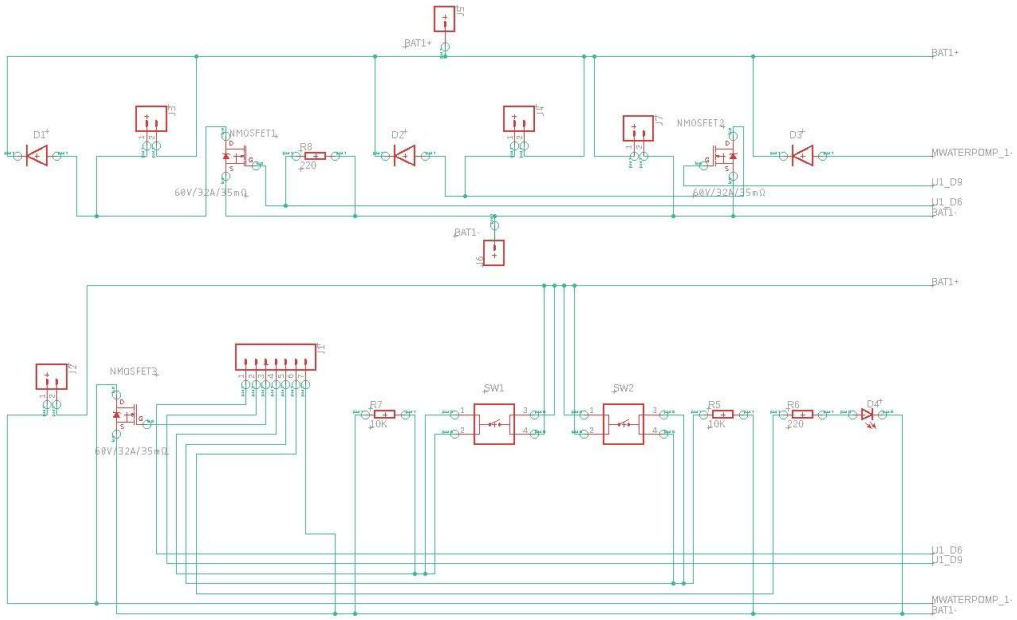


Figure 91 Electrical Diagram. (own author).

6.3 Assembling

To assemble this complete system, first, the 3D-printing was used for all the components needed to complete the external casing. The printed hand box served as the platform for mounting the servo motors, each supported by small bridges for stability.

Within the hand box, the scrubbers were strategically connected to the motors, forming an integral part of the internal mechanism. The water pumps required careful placement inside the hand box, with tubing extending both to the hand box itself and to the water tank.

For water distribution, one water pump directed a tube to the upper section of the hand box, facilitating hand moistening. Simultaneously, its other tube led to a reservoir containing clean soap water. The second water pump's configuration involved a tube connecting to the base of the hand box for collecting used water, while the second tube led to a dedicated tank for storing dirty water.

External to the hand box, the two fans were mounted onto the outer casing, strategically positioned with 2mm-diameter holes to ensure a continuous flow of fresh air. A distribution system, placed atop the fans, efficiently channelled compressed air to the hand box's input and output point. Activating the fan triggered the distribution tubes to facilitate the air's role in the hand-drying process.

Beneath the hand box, safely sheltered from water exposure, a waterproof container housed the battery and Arduino with the PCB, ensuring the integrity of the electronic components.

6.4 Quality Control and Testing

The chapter on 'Quality Control and Testing' provides a detailed examination of ensuring product excellence and meeting regulatory standards. It includes subchapters on 'EU Regulations,' 'CE Certification,' and 'Arrange Appointment Testing.' 'EU Regulations' outlines stringent standards set by the European Union, 'CE Certification' explains the requirements for conformity, and 'Arrange Appointment Testing' details practical quality control measures. This chapter offers insights into maintaining high-quality standards and meeting regulatory criteria in product development and distribution.

6.4.1 EU Regulations

Regarding Durable Components

The European Parliament has introduced regulations aimed at enhancing the sustainability, durability, and performance of batteries. These regulations focus on mitigating the environmental impact of batteries by promoting resource efficiency, recycling, and improved overall functionality (European Parliament, 2023). Key aspects of the regulations include:

1. Sustainability: Emphasizing the use of environmentally friendly materials in battery production and encouraging energy-efficient designs to reduce the ecological footprint of batteries.

2. Durability: Promoting measures to extend the lifespan of batteries, thus reducing the frequency of replacements and minimizing waste.

3. Recyclability: Addressing the recyclability of batteries by setting standards for the use of recyclable materials and establishing systems to facilitate proper disposal and recycling.

4. Resource Efficiency: Encouraging efficient use of resources in battery manufacturing processes and promoting the development of technologies that optimize energy consumption.

5. Performance Standards: Establishing criteria for improved battery performance, ensuring that batteries meet high-quality standards and contribute positively to the overall efficiency of electronic devices.

These regulations collectively aim to create a more sustainable and environmentally responsible approach to battery production, usage, and disposal within the European Union. These represent a commitment to reducing the environmental impact of batteries while fostering innovation and technological advancements in the field (European Parliament, 2023).

Applying the European Parliament's regulations on sustainable batteries to a device designed to clean and dry dirty makeup hands, which includes a battery (power bank), two water pumps, four stepper motors, and an air-blower, involves adopting environmentally responsible practices throughout the device's lifecycle. These regulations indicate that the device should have a life cycle assessment. Every material should be recyclable in the product.

Conduct a comprehensive life cycle assessment of the entire device to evaluate its environmental impact from production to disposal.

Implement measures to minimize waste, maximize recyclability, and ensure responsible disposal practices.

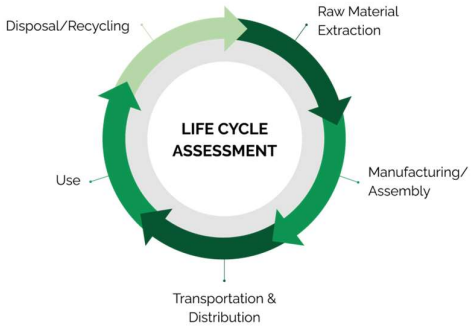


Figure 93. Life Cycle Assessment. (Eckelman, n.d.).

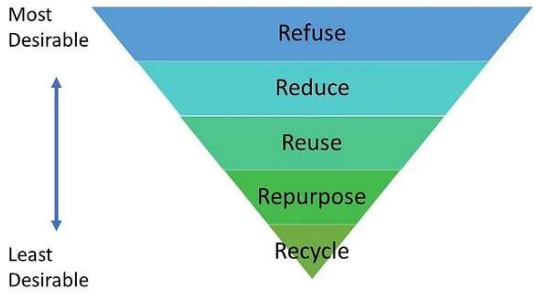


Figure 92. 5Rs of waste management. (w2r Solutions, n.d.).

Table 15. 5R Approach per component.

Component	Approach 5Rs
Silicone pads	**Refuse**, silicone has a lifespan of 20 years (Viking Extrusions, n.d.). Thus there is no cause for concern.
Stepper Motor	**Refuse**, a stepper motor has a lifespan of 10.000 hours (Anaheim Automation, n.d.).
Water Pump	**Refuse**, Diaphragm Pumps can last more than 10 years (Carling, 2015).
Silicone Tubes	**Refuse**, silicone has a lifespan of 20 years (Viking Extrusions, n.d.). Thus there is no cause for concern.
Blow-dryer	**Refuse**, the specification indicates that the air blower has a lifespan of 100,000 hours.
3D-printed material (PLA)	**Recycle and Refuse**, PLA has deemed the most environmentally friendly printable polymer because it isn't derived from fossil fuels and possesses degradability under specific environmental circumstances (Castanon-Jano et al., 2023). That is why it contributes to a circular economy (Recycle). Furthermore, when PLA is kept at typical room temperature, its longevity can extend significantly, perhaps lasting anywhere from 12 to 18 years (Monofilament Direct, n.d.). This also leads to the Refuse segment where the device can last long enough.
Li-Ion Battery	**Refuse**, Lithium batteries last around 600 to 1000 lifecycles (USB Memory Direct, n.d.), taking into account that the device should recharge every week, this would mean the component can at least last 12 years. This is higher than the desired lifespan of a vacuum cleaner of 10,3 years and around the desired lifespan of 12,7 from a washing machine, see Figure 67.
Plastic Bag	**Reuse**, there are multiple ways to reuse plastic bags, e.g. making a plastic wallet (The Spruce, n.d.).
Water Lock	**Refuse**, Automatic coffee machines can last over 10 years when these are well maintained. (Quench Essentials, n.d.).
Silicone anti-slip	**Refuse**, silicone has a lifespan of 20 years (Viking Extrusions, n.d.). Thus there is no cause for concern.

(own author).

The European Commission has introduced a 'right to repair' initiative aimed at reducing costs for consumers and promoting a circular economy. This right encompasses various aspects, including repair within the legal guarantee period, post-expiry of the legal guarantee, and the ability for consumers to repair.

Repair rates are influenced by product type, and cost is a significant factor discouraging consumers from pursuing repairs. Research indicates that consumers prefer easily repairable products, though the willingness to pay for such items depends on the product type and how reparability information is presented.

Existing EU contract laws allow consumers to have faulty products repaired during the legal guarantee, and eco-design rules mandate spare parts availability for a specified time. The European Parliament has been advocating for improved consumer repair rights for over a decade, adopting resolutions in this parliamentary term with concrete proposals for systematic, cost-efficient, and appealing repairs (European Parliament, 2022).

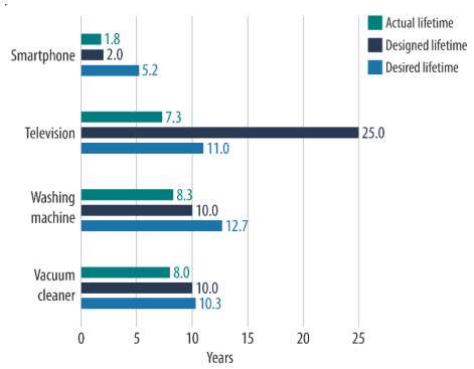


Figure 94. The lifetime of electrical and electronic products. (European Environment Agency, 2020).

In Figure 60 it is also stated that customers desire a higher lifetime than the current actual lifetime. That is why it is required that in the design this will be taken into account.

For these regulations, there would be a solution when the power bank would be easy to replace. The solution for this in the design is to make it easy to replace the battery. This could be done using two hooks (see orange sketches in Figure 66) with an addition of a rubber band (green sketch). This could make the device suitable for these EU regulations.

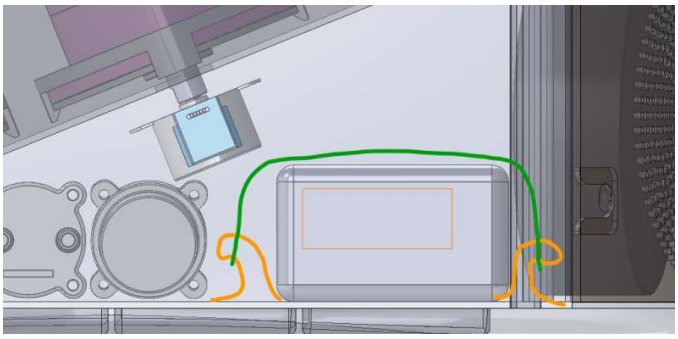


Figure 95. Sketch of making the battery easy to replace. (own author).

Secondly, a box can be made where the PCB and the power bank can be stored (see Figure 67). The PCB is blue-marked marked and the box is marked black. The edges which will not fit in the design will be adjusted in the definite design. This box has two functions:

- Providing a waterproof cabin where all crucial electrical parts can be stored safely. The waterproofing will be done via waterproof tape.

- Providing as the foundation of the hand box, so this part is not obligated to be glued. This will ensure that the customer can replace for instance the battery or repair the electronic parts. Therefore the product will comply with the EU regulations.

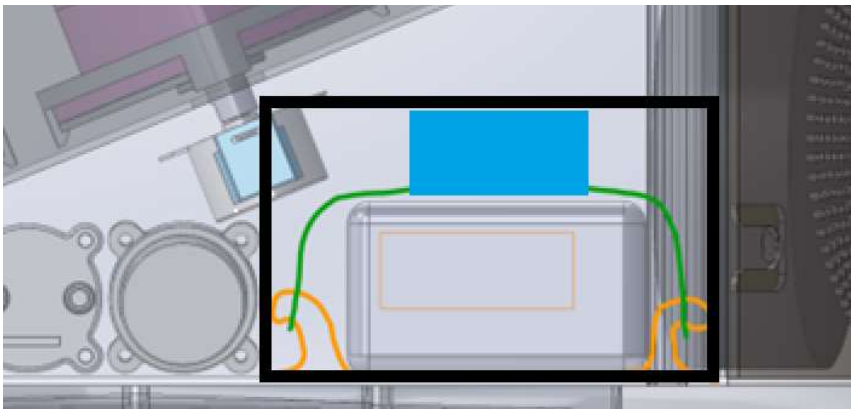


Figure 96. Sketch of position PCB and Box. (own author).

6.4.2 CE Certification

Getting CE Certificate

CE marking is mandatory for many products intended for sale within the European Union (EU), indicating compliance with safety, health, and environmental protection standards outlined by the EU. Products from any global location marketed in the EU must bear the CE marking.

Mandatory CE marking applies to products governed by specific EU specifications necessitating its affixation. Some products must adhere to multiple EU requirements simultaneously, obliging manufacturers to ensure compliance with all relevant regulations before applying the CE marking. CE marking cannot be affixed to products not covered by EU specifications mandating its use.

Manufacturers shoulder the responsibility of affirming conformity with all pertinent EU standards. No license is required to attach the CE marking, but several prerequisites must be met:

- Ensure compliance with EU-wide regulations.
- Assess if self-evaluation suffices or if a notified body must be engaged.
- Compile technical documentation proving conformity.
- Prepare and sign an EU declaration of conformity.

Upon affixing the CE marking, manufacturers may be asked by the competent national authority to furnish supporting information regarding CE marking.

Products may require assessment by a notified body as outlined in the applicable legislation. This step is not compulsory for all products, and if necessary, the CE marking must bear the notified body's identification number. Manufacturers can find a suitable notified body in the Nando database.

Manufacturers conducting the conformity assessment themselves incur no fees, whereas engaging a notified body or mandated independent assessments necessitate payment based on certification procedure complexity and product nature.

CE markings must be visible, legible, and permanent, bearing the initials "CE" with uniform letter dimensions no smaller than 5mm unless otherwise specified. The marking can take varied forms while adhering to proportionality guidelines. If the product itself cannot accommodate the CE marking, it can be placed on the packaging or accompanying documents. In cases where products adhere to multiple EU directives/regulations mandating CE marking, accompanying documents must confirm compliance with all applicable regulations (European Commission, 2023).

Self-Assessment or Notified Body?

There is no need for a Notified Body because the voltage of the device is too low for this. For example, the Low Voltage product group has no requirements for this. These regulations are defined as equipment designed for use which contains a voltage between 50 and 1,000 Volts for alternating current (European Commission, 2023). In addition to this, the Voltage of the Makeup Sanitizer is 12 Volts. For that reason, it is not needed to hire a Notified Body. However, the manufacturer must do this.

Steps to affix CE certificate:

- Identify the applicable directive(s) and harmonised standards
- Verify product-specific requirements
- Identify whether an independent conformity assessment (by a notified body) is necessary
- Test the product and check its conformity
- Draw up and keep available the required technical documentation
- Affix the CE marking and draw up the EU Declaration of Conformity (27 KB)

(European Commission, 2023).

Technical Documentation

Technical documentation holds detailed information about a product's design, production, and operation, showcasing compliance with relevant requirements. If you are the manufacturer, several regulations apply when introducing a product to the market:

Create technical documentation before launching the product.

Ensure the documentation is accessible to market surveillance authorities upon product introduction and retain it for 10 years from the market entry date, unless otherwise specified.

This documentation substantiates conformity and supports the EU declaration of conformity, essential for affixing the CE marking.

Guidelines for technical documentation:

- Contact details (yours or your authorized representative's).
- Product description and identification.
- Involved facilities and notified bodies.
- Conformity assessment details and the EU declaration.
- Labelling, usage instructions, compliance regulations, technical standards, parts list, and test results.

Manufacturers should demonstrate the document's storage and upkeep methods.

Language for documentation can be your choice, but translations might be requested by market surveillance authorities in the EU country where the product is marketed.

Risk Assessment:

Assess potential risks associated with your product and align with essential requirements. Document this analysis in your technical documentation, along with explanations on addressing identified risks, often through harmonized standards.

Declaration of Conformity

This mandatory document signifies compliance with EU requirements. Manufacturers or their representatives need to sign it, taking full accountability for the product's adherence to EU law.

Elements of the EU Declaration of Conformity:

- Name, business address, and product identification.
- Confirmation of responsibility.
- Notified body details (if applicable).
- Compliance with legislation and standards.
- Signature, issue date, additional information (if relevant).

For imported goods, the importer must ensure the product is accompanied by the DoC and maintain a copy for ten years post-market entry. Translation into EU-required languages for the declaration is mandatory.

6.4.3 Schedule Appointments Testing

Firstly, the department ‘Beauty and Cosmetics’ was contacted to test the prototype. However, this department did not reply to the email the project group sent (see Appendix 7).

Furthermore, the project group also went to Emotion, a pharmacy store which also sells makeup to inform about the possibilities of testing the device (see Appendix 7).

7 Business Case

The chapter on 'Business Case' forms a foundational aspect within the context of a master's thesis, encompassing critical subchapters including 'Balance Sheet,' 'Income Statement,' and 'Liquidity Budgets.'

This chapter is integral in presenting a comprehensive view of the financial underpinnings essential to substantiate and support the thesis' core argument or research inquiry. 'Balance Sheet' and 'Income Statement' segments provide insights into the financial health, assets, liabilities, and profitability of the subject matter, facilitating a deeper understanding of its economic standing. Meanwhile, 'Liquidity Budgets' shed light on the availability of funds and financial stability.

By delving into these segments, the chapter on 'Business Case' aims to present a thorough financial analysis, offering a substantiated financial analysis.

7.1 Balance Sheet

The balance sheet indicates that the total investment is €360,608.66. This statement sheet contains Fixed Assets and Current Assets. For instance, Ground and Warehouse are together worth €150,000. Furthermore, the production process is worth €120,000 and the needed equipment €10,000. Moreover, the current assets are Supplies, worth €10.000, Prepaid Amounts of €20,608.66 and cash in the Bank of €50,000.

On the contrary, the assets are financed by different sources. For example, private equity contains €10,000. Also, there are multiple loans to finance the business, containing a mortgage total of €150,000 and a Bank Loan of €125,608.66. The bank loan is determined by the resting amount that was needed to finance the business after all the other loans and private equity.

Investment Budget		Finance Budget	
Assets		**Liabilities and Equity**	
Fixed Assets		**PE**	
Ground	€ 100,000.00	Private Equity	€ 10,000.00
Warehouse	€ 50,000.00		
Production Process	€ 120,000.00		
Equipment	€ 10,000.00		
Current Assets		**Long-term debt**	
Supplies	€ 10,000.00	Mortage Ground 2%	€ 100,000.00
Prepaid Amounts (Start-up Costs)	€ 20,608.66	Mortage Warehouse 2%	€ 50,000.00
		Bank Loan 5 years 4%	€ 125,608.66
		Current Liabilities	
Bank	€ 50,000.00	Creditors	€ 75,000.00
Total	**€ 360,608.66**	**Total**	**€ 360,608.66**

Figure 97. Balance Sheet. (own author).

7.2 Income Statement

The income statements indicate what the income of the company will be in three years (Figure 73). Also, all of the costs are included to show a representative amount of money the company will generate.

Income Statement Year 1	Total Year 1
Revenue	€ 350,000.00
M&S Costs	€ 28,000.00
Material Costs	€ 171,303.93
Maintenance Costs	€ 12,000.00
Utility Costs	€ 36,000.00
Start-up Costs	€ 20,608.66
EBITDA	**€ 82,087.41**
Depreciation Costs	€ 11,302.67
EBIT	**€ 70,784.75**
Interest	€ 5,400.00
EBT	**€ 65,384.75**
Taxes	€ 13,076.95
EAT	**€ 52,307.80**

Income Statement Year 2	Totaal jaar 2
Revenue	€ 525,000.00
M&S Costs	€ 42,000.00
Material Costs	€ 256,955.89
Maintenance Costs	€ 12,000.00
Utility Costs	€ 39,600.00
Start-up Costs	€ -
EBITDA	**€ 174,444.11**
Depreciation Costs	€ 11,302.67
EBIT	**€ 163,141.44**
Interest	€ 4,770.00
EBT	**€ 158,371.44**
Taxes	€ 39,592.86
EAT	**€ 118,778.58**

Income Statement Year 3	Total Year 3
Revenue	€ 700,000.00
M&S Costs	€ 56,000.00
Material Costs	€ 342,607.85
Maintenance Costs	€ 12,000.00
Utility Costs	€ 43,200.00
Start-up Costs	€ -
EBITDA	**€ 246,192.15**
Depreciation Costs	€ 11,302.67
EBIT	**€ 234,889.48**
Interest	€ 4,140.00
EBT	**€ 230,749.48**
Taxes	€ 57,687.37
EAT	**€ 173,062.11**

Figure 98. Income Statements. (own author).

The Revenue is €350,000 in the first year. The revenue is calculated by multiplying the sales with the selling price of the product. The data for this is shown in Figure 97.

The first cost is the Marketing and Sales costs. In the first year, it will be €28,000, which is determined by the revenue the company has. The Costs are 8% of the revenue each year. For that reason, these costs are different per year, depending on the amount of the revenue.

The second cost is the Material Costs, which is the cost price times the amount of products that will be sold. Each year this differs, in Table 16 the sales per year are shown. Also, the variable costs are shown (€171.30).

Table 16. Data for Calculating EBITDA.

Variable Costs	€ 171.30
Selling Price	€ 350.00
Sales year 1	1000
Sales year 2	1500
Sales year 3	2000
Annual Maintainance Fees	€ 12,000.00
Utility Costs	€ 36,000.00

(own author).

The third cost is the Maintenance Costs, which contain the amount of €12,000. This is the estimated amount of solving issues from the process line.

The fourth cost is the start-up costs, which are the expenses in the first month. Because in the first month, there is no revenue, these are also costs that need to be taken into account, this is only applicable for the first year.

Then the Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) can be calculated. In the first year, this will be €82,087.41. The Earnings Before Interest and Taxes (EBIT) will be €70,784.75 (the Depreciations are in total €11,302.67). The Earnings Before Taxes are €65,384.75 when the interests containing €5,400 are subtracted. After the corporate taxes, the Earnings After Taxes (EAT) are €52,307. These calculations are also done for the second and third years (see Figure 73).

7.2.1 Cost Price

For the cost price, every component in the product is taken into account, as shown in Figure 74. Firstly, the amount in the batch and the amount of the components that are needed in 1 product is determined. After that, the price of the batch and the price per product are noted/calculated. Then the price per product is calculated. Then the price per product is calculated when the bulk discount of 30% is applied, for the plastic this is not done, because this is already done in the calculation in Figure 75. The final cost price is the sum of the amounts in this column, this amount is €171.30 per product.

Component	Amount in Batch	Needed in 1 Product	Price of Batch	Price per Product	Price per Product in Bulk
Silicone Brushes	2	2	€ 11.37	€ 22.74	€ 15.92
Motors	5	4	€ 16.19	€ 12.95	€ 9.07
Pumps	1	2	€ 11.00	€ 22.00	€ 15.40
Airblowers	1	2	€ 13.14	€ 26.28	€ 18.40
USB Cable	1	1	€ 1.95	€ 1.95	€ 1.37
PCB	1	1	€ 20.00	€ 20.00	€ 14.00
Adaino	1	1	€ 34.76	€ 34.76	€ 24.33
Power Bank	1	1	€ 44.90	€ 44.90	€ 31.43
Plastic (ABS)	1	1	€ 5.86	€ 5.86	€ 5.86
Tubes	4	4	€ 3.09	€ 3.09	€ 2.16
Waterproof tape	1	0.5	€ 18.85	€ 9.43	€ 6.60
Water Lock	1	2	€ 8.99	€ 17.98	€ 12.59
Anti-Slip	207	12	€ 4.99	€ 0.29	€ 0.20
Coupler	4	4	€ 9.99	€ 9.99	€ 6.99
Belt	1	1	€ 9.99	€ 9.99	€ 6.99
Total				€ 242.21	€ 171.30

Figure 99. Calculation Cost Price. (own author).

PART	VOLUME	GRAMS	MATERIAL PRICE	Kind of Mold	Price of Mold (USD)	Price of Mold (EUR)
Cover	243296	253	€ 0.63	Intermediate	$ 5,000.00	€ 4,600.00
Case	989019	1029	€ 2.57	Intermediate	$ 5,000.00	€ 4,600.00
Reservoir 1	253190	263	€ 0.66	Intermediate	$ 5,000.00	€ 4,600.00
Reservoir 2	253190	263	€ 0.66	Intermediate	$ 5,000.00	€ 4,600.00
RCover 1	67596	70	€ 0.18	Basic	$ 1,500.00	€ 1,380.00
RCover 2	67596	70	€ 0.18	Basic	$ 1,500.00	€ 1,380.00
Hand box	297270	309	€ 0.77	Intermediate	$ 5,000.00	€ 4,600.00
SCHolder1	5360	6	€ 0.01	Basic	$ 1,500.00	€ 1,380.00
SCHolder2	5360	6	€ 0.01	Basic	$ 1,500.00	€ 1,380.00
SCHolder3	5360	6	€ 0.01	Basic	$ 1,500.00	€ 1,380.00
SCHolder4	5360	6	€ 0.01	Basic	$ 1,500.00	€ 1,380.00
SCHolder11	10445	11	€ 0.03	Basic	$ 1,500.00	€ 1,380.00
SCHolder12	10445	11	€ 0.03	Basic	$ 1,500.00	€ 1,380.00
SCHolder13	10445	11	€ 0.03	Basic	$ 1,500.00	€ 1,380.00
SCHolder14	10445	11	€ 0.03	Basic	$ 1,500.00	€ 1,380.00
Buttons	20058	21	€ 0.05	Basic	$ 1,500.00	€ 1,380.00
Total	2254436	2345	€ 5.86		$ 41,500.00	€ 38,180.00

Price per kg	Density in g/cm3	Exchange Rate USD/EUR	0.92
2.50	1.04		

Figure 100. Calculation Price Plastic (ABS). (own author).

7.2.2 Interest and Depreciation

In figure 76 the calculation of depreciation of each long-lasting asset is calculated. This is done via the formula '(Cost of an Asset – Residual Value)/ Useful Life Terms'. The total annual depreciation is €11,302.67.

Moreover, the mortgage is calculated. It is chosen that the repayments are equal each year, which means that this loan is linear. That means that the interest costs are different each year, for the income statement it is important to calculate these interest costs, for instance, in the first year these interest costs are €3,000. This is also done for the Bank Loan, then the interest costs of the first year are €2,400. In the end repayments and interests are accumulated, because this is needed to calculate the expenses on the loans. These amounts are spined off in the Liquidity Budget.

Depreciation	Cost of an Asset	Residual Value	Useful Life terms	Annual Depreciation
Warehouse	€ 150,000.00	€ 50,000.00	30	€ 3,333.33
Production Process	€ 38,180.00	€ -	5	€ 7,636.00
Equipment	€ 10,000.00		30	€ 333.33
Total				**€ 11,302.67**

Interest		Amount Beginning of Year	Interest	Repayment	Amount end of Year
Montage 2%	Year 1	€ 150,000.00	€ 3,000.00	€ 7,500.00	€ 142,500.00
	Year 2	€ 142,500.00	€ 2,850.00	€ 7,500.00	€ 135,000.00
	Year 3	€ 135,000.00	€ 2,700.00	€ 7,500.00	€ 127,500.00

Interest		Amount Beginning of Year	Interest	Repayment	Amount end of Year
Bank Loan 4%	Year 1	€ 60,000.00	€ 2,400.00	€ 12,000.00	€ 48,000.00
	Year 2	€ 48,000.00	€ 1,920.00	€ 12,000.00	€ 36,000.00
	Year 3	€ 36,000.00	€ 1,440.00	€ 12,000.00	€ 24,000.00

			Interest	Repayment
Total	Year 1		€ 5,400.00	€ 19,500.00
	Year 2		€ 4,770.00	€ 19,500.00
	Year 3		€ 4,140.00	€ 19,500.00

Figure 101. Calculations Depreciation and Interest.

7.3 Liquidity Budgets

The liquidity budgets from each year are also taken into account. In Figure 77 it is shown that the amounts of each year will be.

Liquidity budget year 1	Total Year 1
Inflows	
Debtors	€ 320,833.33
Total Inflow	**€ 320,833.33**
Expenses	
M&S	€ 28,000.00
Storage	€ 171,303.93
Maintenance	€ 12,000.00
Utilities	€ 36,000.00
Repayment Mortage	
Repayment Bank Loan	€ 12,000.00
Interest Mortage	€ 3,000.00
Interest Bank Loan	€ 2,400.00
Corporate Taks	
Total Expenses	**€ 285,280.88**
Total Cashflows	**€ 35,552.46**

Liquidity budget year 2	Total Year 2
Inflows	
Debitors	€ 525,000.00
Total Inflows	**€ 525,000.00**
Expenses	
M&S	€ 42,000.00
Storage	€ 256,955.89
Maintenance	€ 12,000.00
Utilities	€ 39,600.00
Repayment Mortage	€ 7,500.00
Repayment Bank Loan	€ 12,000.00
Interest Mortage	€ 2,850.00
Interest Bank Loan	€ 1,920.00
Corporate Taks	
Total Expenses	**€ 414,418.75**
Total Cashflows	**€ 110,581.25**

Liquidity budget year 3	Total Year 3
Ontvangsten	
Debiteuren	€ 700,000.00
Total Inflows	**€ 700,000.00**
Expenses	
M&S	€ 56,000.00
Storage	€ 342,607.85
Maintenance	€ 12,000.00
Utilities	€ 43,200.00
Repayment Mortage	€ 7,500.00
Repayment Bank Loan	€ 12,000.00
Interest Mortage	€ 2,700.00
Interest Bank Loan	€ 1,440.00
Corporate Taks	
Total Expenses	**€ 535,135.22**
Total Cashslows	**€ 164,864.78**

Figure 102. Liquidity Budgets. (own author).

8 Results

In this part, the final results obtained are shown, digitally as well as physically.

Contextualized digital design

By transferring the SolidWorks files to KeyShot, a digital rendering software, and integrating the machine with various objects on a table, it becomes possible to visualize the final product's appearance. This visualization aids the viewer in comprehending the machine's size and proportions within a contextual setting.

Figure 103. Contextual Model. (own author).

Final model

This set of images showcases the final version of the model. The first image presents the fully assembled machine, while the subsequent ones depict the machine in an open configuration, revealing its internal components.

Figure 104. Final Model. (own athor).

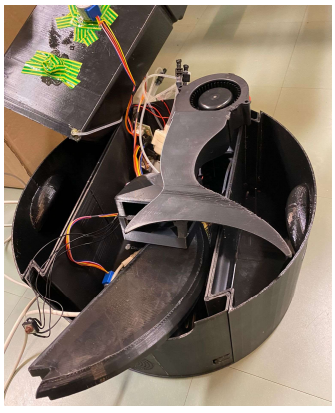


Figure 105. Open View Final Model. (own author).

Conclusion

The central question addressed was: "How can a neutrally coloured portable prototype be developed to clean and dry makeup-covered hands without causing a dry sensation on the skin?" The process began by defining customer needs, leading to the creation of an initial design. Subsequent feedback from the customer informed adjustments to the prototype's design. The fabrication involved 3D printing using PLA material, concurrently with the assembly and compilation of electronic components, including the PCB, Arduino, and cables.

On the design side, the current iteration of the machine is deemed satisfactory but has room for improvement in nearly every aspect. Time constraints and the urgency to quickly design components have resulted in pieces that fall short of their optimal quality. Moreover, the limited experience and expertise in designing for 3D printing manufacturing have contributed to the design's shortcomings. Given more time, it would have been beneficial to adhere to the principles of DFMA (Design For Manufacturing and Assembly) throughout the entire product design process.

The less-than-optimal design of the components posed challenges during assembly. While the computer simulations suggested a seamless fit, the actual construction of the prototype revealed numerous issues. One notable problem was the inaccessibility of certain screws, necessitating the creation of additional holes in the parts post-design to facilitate assembly.

The manufacturing process for frames and electronics proceeded independently before the final assembly of the product. Although attempts were made to test the prototype with the Beauty and Cosmetics Department at Novia and a local cosmetics store, both did not respond. Unfortunately, the brief timeframe prevented the execution of a fully operational prototype. While the current prototype is functional when the hand is not inside, it faces operational limitations due to the low power of the motors.

Nevertheless, the manufacturing of the current prototype led to significant improvements, such as the adjusted hand entrance and the suggested water valve for the reservoirs. It highlighted the need for stepper motors with a minimum of 12 Volts to manage tension with the scrubber and inertia caused by the scrubber's weight.

Recommendations

The following recommendations are requested for further research. First of all, the system needs to be 12 Volts as a whole, this is because the current motors are not strong enough to wash hands. This is because of the tension and inertia from the scrubbers. Secondly, the suggestion is to find a way to fasten the battery to the case and make it removable. This can be done for instance via the bottom. Thirdly a charging port can be added to the device, so the product can be charged with ease. The rest of the recommendations can be found in Appendix 6.

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Appendix 1. Belbin Roles

Table 17. Belbin Roles. (Belbin, n.d.).

Type	Description	Strengths	Weaknesses
Creators			
Plant	Tends to be highly creative and good at solving problems in unconventional ways.	Creative, imaginative, free-thinking, generates ideas and solves difficult problems.	Might ignore incidentals, and may be too preoccupied to communicate effectively. These people could be absent-minded or forgetful.
Resource Investigator	Uses an inquisitive nature to find ideas to bring back to the team.	Outgoing, enthusiastic. Explores opportunities and develops contacts.	Might be over-optimistic, and can lose interest once the initial enthusiasm has passed. This person might forget to follow up on a lead.
Leaders			
Coordinator (Chairman)	Needed to focus on the team's objectives, draw out team members and delegate work appropriately.	Mature, confident, identifies talent. Clarifies goals.	Can be seen as manipulative and might offload the share of the work. Coordinators might over-delegate, leaving members little work to do.
Shaper	Provides the necessary drive to ensure that the team keeps moving and does not lose focus or momentum.	Challenging, dynamic, thrives on pressure. Has the drive and courage to overcome obstacles.	Can be prone to provocation and may sometimes offend people's feelings. Shapers could risk becoming aggressive and bad-humoured in the attempts to get things done.

Introducers			
Team Worker	Helps the team to gel, using the versatility to identify the work required and complete it on behalf of the team.	Co-operative, perceptive and diplomatic. Listens and averts friction.	Can be indecisive in crunch situations and tends to avoid confrontation. Team workers might be hesitant to make unpopular decisions.
Implementer, (Company Worker)	Needed to plan a workable strategy and carry it out as efficiently as possible.	Practical, reliable, and efficient. Turns ideas into actions and organises work that needs to be done.	Can be a bit inflexible and slow to respond to new possibilities. Implementers might be slow to relinquish plans in favour of positive changes.
Finishers			
Monitor Evaluator	Provides a logical eye, making impartial judgements where required and weighs up the team's options in a dispassionate way.	Sober, strategic and discerning. Sees all options and judges accurately.	Sometimes lacks the drive and ability to inspire others and can be overly critical. Finishers could be slow to come to decisions.
Completer (Finisher)	Most effectively used at the end of tasks to polish and scrutinise the work for errors, subjecting it to the highest standards of quality control.	Painstaking, conscientious, anxious. Searches out errors. Polishes and perfects.	Can be inclined to worry unduly, and reluctant to delegate. Completers could be accused of taking perfectionism to extremes.
Specialists			
Specialists	Bring in-depth knowledge of a key area to the team.	Single-minded, self-starting and dedicated. This type of person provides specialist knowledge and skills.	Tends to contribute on a narrow front and can dwell on the technicalities. Specialists overload information.

Reflection per Team Member

Guyon De Abreu

The evaluation highlights strong coordination and teamwork skills, pivotal in driving academic and professional success.

Figure 106. Results Belbin Test Guyon. (own author).

Coordinator:

Project Organization: I excel in organizing intricate projects, and efficiently managing timelines, resources, and communication channels. Whether in academics or internships, my meticulous planning ensures seamless execution.

Attention to Detail: My keen attention brings confidence to the team, as people trust me to identify and resolve potential issues before escalating.

Adaptive Problem Solving: I thrive under pressure, swiftly adapting to unforeseen challenges and providing innovative solutions in various group projects and workplace scenarios.

Team Worker:

Active Collaboration: I actively engage in collaborative efforts, fostering an environment where diverse perspectives are valued, and ideas flow freely.

Effective Communication: I prioritize clear and empathetic communication, reducing misunderstandings and promoting harmonious team dynamics.

Conflict Resolution: I approach conflicts constructively, seeking win-win solutions and strengthening team cohesion.

Santiago Sanz

Figure 107. Results Belbin Test Santiago. (own author).

I must say that I generally agree with these outcomes from the Belbin Test. However, I do not fully agree with all aspects.

The "Plant" role describes individuals who are creative, innovative, and often produce unconventional ideas. Plants are the "idea generators" in a team. This resonates with me as I have always been drawn to brainstorming sessions and problem-solving activities. I tend to think outside the box and enjoy exploring new and uncharted territories in various projects. I find this aspect of my role to be both exciting and fulfilling.

The "Specialist" role, on the other hand, represents individuals who possess in-depth knowledge and expertise in a particular field. Specialists are the go-to people for information and often provide valuable insights based on deep understanding. This, too, aligns with my experiences and preferences. I have always had a penchant for delving deep into subjects that interest me, and I take pride in being a reliable source of information and assistance when it comes to those areas.

In essence, the Belbin test has shed light on my strengths within a team. I am not only the one who can think creatively and offer new perspectives but also the person who can bring a wealth of knowledge and expertise to the table. Recognizing these roles has provided me with a deeper understanding of my contributions within a team setting, and it is reassuring to see that the test results align with my self-perception.

Understanding my primary roles as a "Plant" and a "Specialist" encourages me to embrace these strengths and use these to benefit my performance. It also highlights the importance

of working in diverse teams where different roles complement each other. I look forward to more opportunities to collaborate with others, capitalizing on these roles to achieve collective success.

Sabine Welmerink

Implementor:

An implementor has to be good at communicating with the other team members. Also, an implementor would have to make sure that the jobs are finished as planned in the agenda. Implementors oversee the progress of tasks and ensure the fulfilment on time within budget.

Figure 108. Results Belbin Test Sabine. (own author).

I can agree with that the implementor came out the test with 9 points. I do identify as all of the above.

Shaper:

Shapers tend to be results-oriented and have a strong desire to overcome obstacles and achieve goals. Shapers can be highly energetic and are not afraid to confront and address issues that may hinder the team's progress. Shapers' confidence and competitive nature can sometimes lead to conflicts within the team. On the contrary, shapers may come across as impatient or too critical, which can affect team dynamics. Shapers need to balance drive with diplomacy and teamwork.

I can agree with the results-oriented and the strong desire to overcome obstacles and achieve goals. The only thing I do not identify as is the impatient or too critical. I know that I can be critical, but I think that is not too much.

Resource Investigator: Resource Investigators are skilled at identifying potential opportunities, whether it is finding new suppliers, partners, or innovative solutions. Resource investigators often have a keen eye for spotting gaps and areas where the project can benefit from external resources. When obstacles or challenges arise, Resource Investigators can tap into network and information-gathering skills to find creative solutions. Resource Investigators can connect the team with experts or resources that can help overcome hurdles.

About the creative solutions, my opinion deviates from the result. Finding new suppliers is something I have not worked on that much, besides online suppliers like Amazon, etc.

Complete Finisher:

The complete finisher would be responsible for ensuring that all tasks and project components are completed on time and to the required standards. This includes tracking progress, following up on outstanding tasks, and making sure nothing is left unfinished.

I can agree with this task. Usually, I like to make sure that everything is done correctly before finalizing the product.

Specialist: Specialists are typically experts in a particular field or discipline, and primary role is to provide in-depth knowledge and guidance related to that subject. Specialists are expected to have a deep understanding of the topic and stay up-to-date with the latest developments.

I think that my speciality as a Mechatronics student can be good for this project. As it will be covering almost every Engineering aspect in general.

Appendix 2. WBS

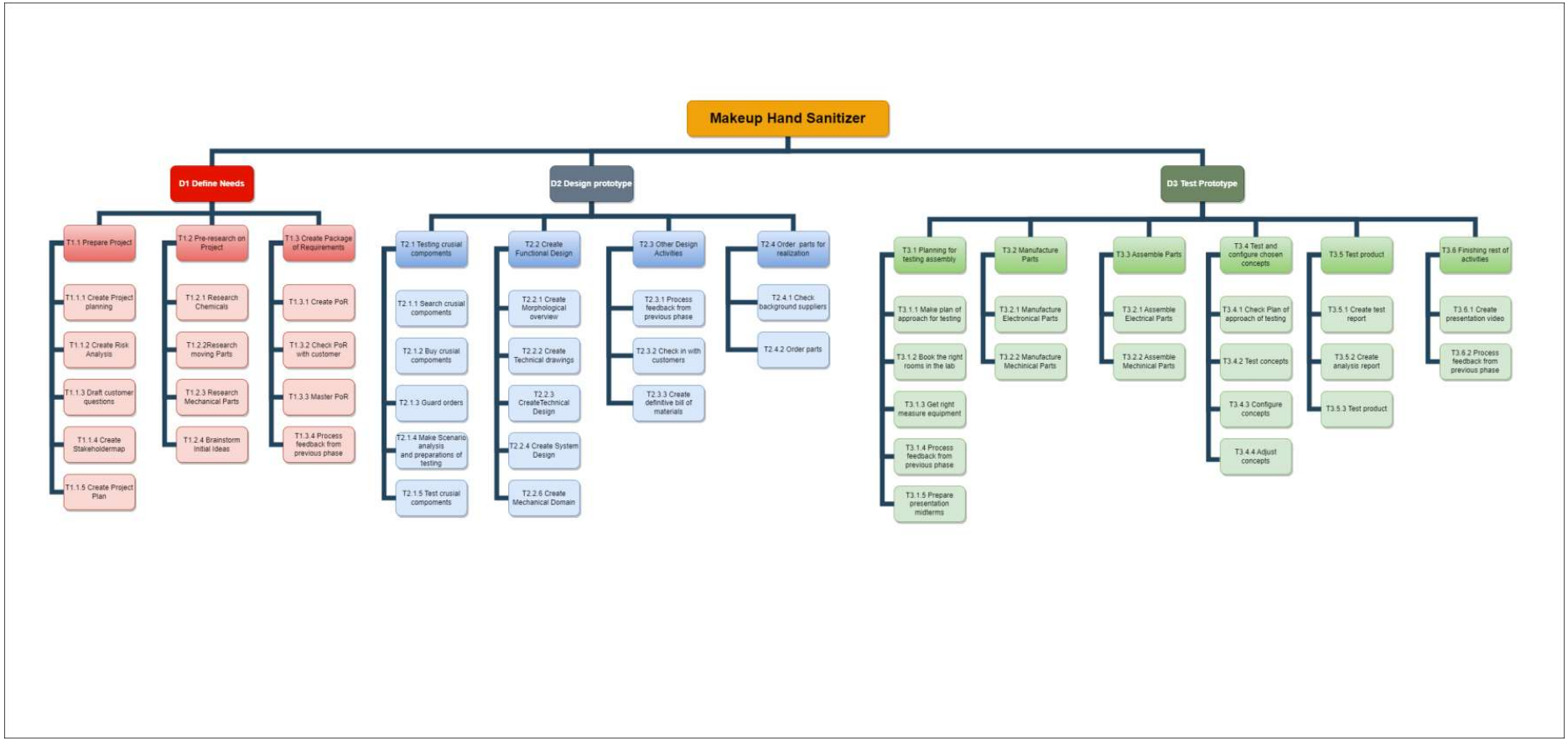

Figure 109. WBS. (own author).

Appendix 3. Gantt Diagram

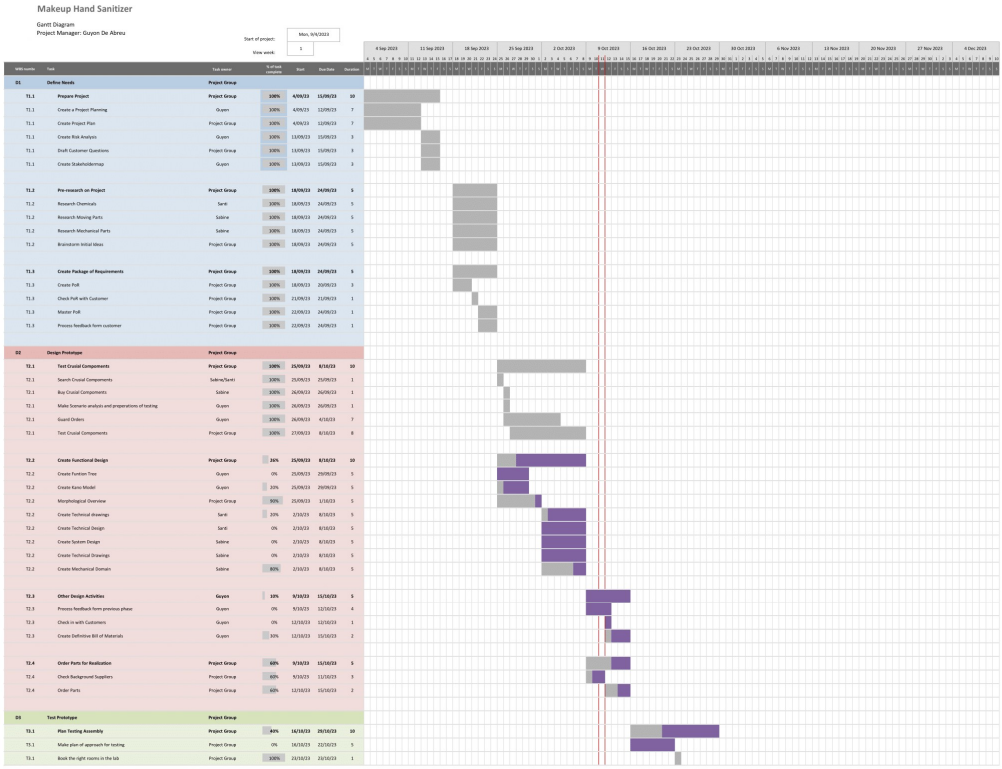

Figure 111. Upper Gantt Diagram. (own author).

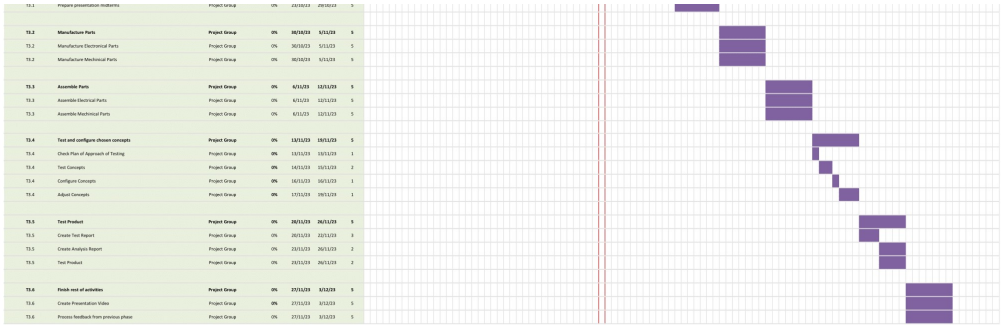

Figure 110. Lower Gantt Diagram. (own author).

Appendix 4. Explanations Stakeholder Management

Explanation Interests and Influence

Project Group (Internal)

Interests (Grade 3): The project group is highly interested in the project's success because this group is directly responsible for its execution. Performance, reputation, and potential careers of the members are closely tied to the project's outcome.

Influence (Grade 3): The project group has a significant influence on the project as the members are responsible for its execution. The team has control over project decisions and actions.

Josefin Stolpe (Internal)

Interests (Grade 3): As a supervisor, Josefin Stolpe is highly interested in the project's success. Josefin's reputation and role effectiveness are connected to the project's outcomes.

Influence (Grade 2): While Josefin plays a crucial role in providing guidance and monitoring progress, Josefin's influence is somewhat limited compared to the project team.

Christina and Isabel Bjon (Internal)

Interests (Grade 3): As customers provide feedback on the prototype, these stakeholders are highly interested in the project's success because the prototype's quality directly affects the stakeholders.

Influence (Grade 2): The Customer's influence is primarily in providing feedback and requirements for the project, which is important but not as substantial as the project teams.

Hans Lindén (Internal)

Interests (Grade 3): Hans Lindén, as both a customer and supervisor, is highly interested in the project's success. His responsibilities and reputation are closely tied to the project's outcome.

Influence (Grade 2): Similar to Josefin has a significant role but may not have as much influence as the core project team.

Novia University (Internal)

Interests (Grade 2): Novia University is interested in the project results as it is an educational institution, but its interests are not as directly linked to the project's success as the project team or customers.

Influence (Grade 1): While the university may have some influence over the project through academic policies, it is likely limited compared to the project team and customers.

Suppliers (External)

Interests (Grade 2): Suppliers have an interest in delivering components on time and ensuring quality because it affects business and reputation.

Influence (Grade 1): Suppliers have limited influence over the project beyond providing materials, as these are external parties.

Home Universities (External)

Interests (Grade 2): Home universities are concerned about the project's impact on students' grades and academic progress, but the interests are somewhat removed from the project's technical success.

Influence (Grade 1): Home Universities have limited influence over the project's technical aspects, but these may have control over students' participation.

Philip Hollins (External)

Interests (Grade 1): Philip Hollins is primarily interested in providing information and guidance about project management, and his interests are not directly tied to the project's technical success.

Influence (Grade 1): While Philip can guide the planning and objectives, his influence over the project's execution is limited.

Explanation Trust and Agreement

Project Group (Internal)

Trust (3): The project group is highly trusted since members are the core team responsible for the project's success. There is a high level of confidence in the ability to deliver within scope, time, and budget.

Agreement (3): There is a strong agreement among all stakeholders, including the project group, about the project's objectives and success criteria.

Josefin Stolpe (Internal - Supervisor)

Trust (3): As the supervisor, there is a high level of trust in Josefin Stolpe's guidance and monitoring capabilities.

Agreement (1): There is some disagreement about the level of agreement concerning the project's objectives and success criteria, which may be influenced by the supervisor's role.

Christina and Isabel Bjon (Internal - Customers)

Trust (3): There is trust in Christina and Isabel Bjon's ability to provide valuable feedback on the developing prototype.

Agreement (2): While there is general agreement on the importance of customer feedback, there may be some differences in expectations or requirements.

Hans Lindén (Internal - Customer and Supervisor)

Trust (1): Trust in Hans Lindén may be lower due to a low level of communication in ordering parts.

Agreement (2): Hans Lindén can indicate that parts from outside of the EU are not orderable. But also some parts inside the EU can be ordered, so that is why this stakeholder scored 2.

Novia University (Internal - Educational Institution)

Trust (2): Trust in Novia University is moderate as the primary concern is the project's academic impact rather than technical success.

Agreement (3): There is a high level of agreement among stakeholders regarding the importance of project results for the educational institution.

Suppliers (External)

Trust (1): Trust in external suppliers may be lower due to concerns about the ability to deliver components on time and ensure quality.

Agreement (3): Despite trust issues, there is strong agreement on the importance of timely delivery and component quality.

Home Universities (External)

Trust (3): There is a high level of trust in the home universities' concern for students' grades and academic progress.

Agreement (3): There is strong agreement on the importance of grades and academic credit for participating students.

Philip Hollins (External)

Trust (2): Trust in Philip Hollins is moderate as his role primarily involves providing information and guidance on project management.

Agreement (2): There is moderate agreement on the value of Philip Hollins' guidance for project planning and objectives.

Appendix 5. Risk Register

ID	RISK DESCRIPTION	Risk Type	IMPACT DESCRIPTION	IMPACT LEVEL	PROBABILITY LEVEL	PRIORITY LEVEL	RESPONSE NOTES	RESPONSE	OWNER
	Give a brief summary of the risk	What sort of Risk is it?	What will happen if the risk is not mitigated or eliminated?	Rate 1 (LOW) to 5 (HIGH)	Rate 1 (LOW) to 5 (HIGH)	(IMPACT X PROBABILITY) Address the highest first	What action will the project group take?	Fill in: Accept, Reduce, Transfer, or Avoid	Who's responsible?
A	Christina and/or Isabel Bjon are not available	Communication	There is no sufficient communication, which means that information is missed.	3	2	6	This risk can be reduced by planning meetings ahead and keeping the customer informed.	Reduce	Sabine
B	Insufficient knowledge regarding programs, components or processes	Lack of knowledge	It is not possible to work sufficiently with the programs/products.	5	3	15	This risk can be avoided by using other programs/products. In addition, there is an opportunity to consult university staff for help or explanation about the problem. As well as desk researching.	Avoid	Sabine, Santiago
C	The delivered components are, when the end product has to be delivered, no longer working	Defective components	There are not enough components to work with.	5	1	5	The project group can transfer the risk by finding a new supplier in the area of Vaasa.	Transfer	Project group
D	The delivered components are, when the end product is going to the test phase, no longer working	Defective components	The project will get delays.	5	2	10	The project group can transfer the risk by finding a new components in the area of Vaasa.	Transfer	Project group
E	The water hits the electronical parts and causes a short circuit	Short circuit	The electrical part of the prototype will not work.	5	4	20	This can be avoided by making sure that the reservoir is waterproof and the wiring is sealed correctly. Also position the water reservoir at distance from wiring as much as possible, at a proper distance from the electronical parts.	Avoid	Sabine, Santiago
F	This prototype carries risks with not containing environmental friendly materials and chemicals.	Environmental Impact	Bad public reputation and/or violating regulations.	2	3	6	This risk can be reduced by making sure that research is done about what components are durable. Another way to reduce this risk is to do an environmental assessment when the product is ready.	Reduce	Project group
G	There could be issues in testing the product properly	Delays	It will cause delays, so the project group will need to reschedule.	4	4	16	Avoid this by planning the test phase early, so there is enough time to solve the issues.	Avoid	Sabine, Santiago
H	Risk related to not complying with regulations and standards for the production and labelling of hand sanitizers	Compliance	Non-compliance could result in legal issues or delays in product launch.	2	2	4	Accept the risk, but also research Finnish regulations about skin care devices.	Accept	Guyon
I	The chosen solution is not technically feasible	Delays	It will cause delays, so the project group will need to reschedule.	5	2	10	The project group can transfer the risk by consulting an expert.	Transfer	Project group
J	IT problems	Communication	It will cause delays and worse communication with the stakeholders.	3	3	9	Reduce the risk by consulting with the IT department.	Reduce	Project group

External risks

ID	RISK DESCRIPTION		IMPACT DESCRIPTION	IMPACT LEVEL	PROBABILITY LEVEL	PRIORITY LEVEL	MITIGATION NOTES	RESPONSE	OWNER
	Give a brief summary of the risk		What will happen if the risk is not mitigated or eliminated?	Rate 1 (LOW) to 5 (HIGH)	Rate 1 (LOW) to 5 (HIGH)	(IMPACT X PROBABILITY) Address the highest first	What can be done to lower or eliminate the impact or probability?	Fill in: Accept, Reduce, Transfer, or Avoid	Who's responsible?
K	Delivery components delayed	Delays	It can disrupt project schedule and potentially causing delays and affecting project quality.	3	2	6	Reduce the risk by ensuring the due date of the product's delivery is a week before it is needed	Reduce	Project group
L	Components are not available	Delays	It can disrupt project timelines and potentially causing delays and affecting project quality.	4	2	8	Transfer risk by researching alternative components for the most crucial parts (morphological overview)	Transfer	Project group

Figure 112. Risk Register. (own author).

Appendix 6: Emails Testing

Dear Jaana,

I trust this message finds you well. Our names are Guyon, Santiago and Sabine, we are international students who participate in the European Project Semester. We are working on an innovative device designed for the efficient cleaning and drying of dirty makeup hands.

Our device envisions to revolutionize the beauty industry by providing a quick and effective solution for makeup artists. We believe that the insights and feedback from esteem-programme students would be immensely valuable in refining our device.

We are enthusiastic about the possibility of having students from your program test our prototype. This hands-on experience will not only benefit our project but also offer students a unique opportunity to engage with cutting-edge technology in their field of study.

We anticipate completing the device by December 13th and would appreciate the opportunity to coordinate a testing session shortly after. Your collaboration in this endeavour would be invaluable to us.

Could we discuss the details further, perhaps through a meeting at your convenience? We look forward to the prospect of working together and benefiting from the expertise of the esteem-programme.

Thank you for considering our proposal, and we are eager to hear your thoughts.

Best Regards,

Guyon De Abreu

Figure 113. Email sent to Head of Degree Program Beauty and Cosmetics. (own author).

Hey Tiina,

We hope this email finds you well. We are Guyon, Sabine and Santiago, international students at Novia University. Our team is developing a cutting-edge device for cleaning and drying makeup-covered hands.

Yesterday we spoke with one of your employees, Tiina Hota, she referred us to you for testing this device at your store. We'd love to collaborate with makeup enthusiasts to gather feedback. We aim to finalize the product by December 13. In the attachments, you can find a picture of the device.

Could we discuss this opportunity further? Your input would be invaluable.

Kind Regards,

Guyon De Abreu

Figure 114. Email sent to the Cosmetics Store. (own author).

Appendix 7: List of Recommendations

Table 18. Recommendations for further research.

Number	Recommendation
1	Change system to 12 Volts
2	Handle for the lid
3	A system so the user does not need to take out the whole lid
4	Transparent line for seeing the water level in reservoirs
5	System to fasten the hand box to the frame
6	Expand the hand box width
7	Consider horizontal orientation for the hand box, to save space
8	Adjust the little box for Arduino and PCB
9	Find a way to fasten the battery to the case and make this easily removable
10	Opening from the bottom of the device to change the battery
11	Add a charging port for the device
12	Connections from water tanks to the inside can be designed so it is more efficient
13	Make holes in the hand box for air channels
14	A small convenient accumulator as a battery
15	PCB with 90% of wiring
16	Converter for pumps, because the system is recommended to be 12 Volts
17	Insert the stepper converter into the PCB

(own author).