Developing a design tool for **The Robot Facebook**

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Abstract

The use of robotics has been growing constantly, resulting in a large range of robots. And each of them with a unique appearance. In this research, I demonstrated an effective method in which information from The Robot Facebook is communicated to designers in order to help them develop improved robot faces. The Robot Facebook is a database of 107 successful robot faces and while this database provides a good overview, it lacks dynamic interaction which helps users in creating better robot faces.

The visual appearance of the robot is important because it shapes the user's experience. It influences the expectations of a robot, both expectations of behaviour and functionality. The purpose of a robot's face is to convey emotions through expression and some types of facial features are better at doing this than others.

The requirements of different stakeholders were gathered through interviews. Next to that, several types of design tool ideas have been explored, which eventually led to the realisation of a Hi-Fi prototype. This prototype is a design tool that allows users to create a robot face in a conscious, informative way. The tool uses labels and examples from the database and they were transformed into cards. The illustrations of these cards are added as a separate layer. This way the illustrations are detachable from the cards and can be reattached to the framework part of the tool. On this framework, users can design a new robot face. The other side of the design tool informs users about the expression of the design they are making through the use of sliders.

The design tool was tested with stakeholders through interaction, which was followed up with an interview. The tool was positively received by participants. They were able to make a conscious, relevant design without requiring background research. While the design tool could focus more on the informing aspects, it is an effective way of communicating information from The Robot Facebook to designers and helps them make better robot faces.

Acknowledgements

Writing this thesis was a daunting and time-consuming task, which definitely has not always been easy. I want to thank my supervisor Edwin Dertien and Robby van Delden for providing feedback and having good discussions during meetings. Their comments and insights helped get this project to where it currently is at.

I would also like to thank my friends and family for being my support system during this project. For always being a listening ear when I had another idea, and even offering critical feedback on them. Without these people, this project would not have succeeded the way it did.

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1. Introduction

The use of robots has been growing continuously within modern society. They find their practice in almost every sector; from helping the elderly to feel less alone to efficiently packing orders in warehouses. In the future, it may even be that a personal robot assistant will help perform chores around the house, and even feel like a social companion to us. All these robots have different appearances, some appear mechanical and others are intended to look very human-like. In 2017 a collection of around 100 robot faces was made by Eva Velt, named 'The Robot Facebook' [1]. This is currently displayed on a website [2].

Attributes of different features have been used to categorise all the robot faces. The main categorisation consists of the categories: *cartoonish, human-like, function defines form, helmets and anthropomorphic.* Second, more detail-specific attributes are used, such as eye shape and type of mouth. These attributes help create a good overview of the current State of the Art. Next to building this database, analysis and data physicalization have been executed on the data, resulting in relevant information on robot faces.

The visual design of the robot's face is important for the overall experience of the users while interacting with it. When a robot has a very unsettling face, users are less likely to approach it. Next to this, the appearance influences the expectations of the functionality of the robot. For example, when interacting with a human-like robot, people expect that it communicates similarly to real humans. The face plays a crucial part in how the robot is perceived. Therefore, being aware of the effects of visual appearance is, and designing a new robot (face) based on this information is important.

The database of around 100 robot faces serves as a good overview of the current State of the Art of robot faces. However, the current form of the database limits the applicability of the information. Large chunks of information are currently displayed simultaneously, limiting the designers to differentiate which elements of the face are important.

Therefore within this project, the goal is to develop a tool that takes this information from The Robot Facebook and makes it more functional for designers. This tool should help guide designers to make better robot face designs.

1.1 Research questions

In order to meet the goal of developing a tool for The Robot Facebook, a set of research and sub-questions have been created. Answering these questions will help guide the project to its final goal.

Main-RQ: How to effectively communicate information from The Robot Facebook to designers to help them design better robot faces?

To find a detailed answer to this question, several aspects were investigated. Relevant design methods need to be investigated to see which tool is the best applicable to the current situation. And this also leads to the following sub-question:

Sub-RQ1: What database design tool or methods are there that help designers in their design process?

By combining the knowledge of design tools with related examples, inspiration for the new tool can be drawn. The next step is to obtain the information designers need to make improved robot faces. Hence, the following sub-question:

Sub-RQ2: What insights do designers need to make better robot faces?

By answering this question, knowledge is gained on the aspects the tool should contain. When knowing this, it can be taken into consideration what kind of tool would be best within this context. This leads to the final sub-question, which eventually leads to answering the main research question.

Sub-RQ3: What tool is most effective to help designers make better robot faces?

By combining all the knowledge from answering the previously mentioned sub-questions, enough information is collected to develop a tool that helps designers make better robot faces. Therefore giving a possible answer to the main research question.

1.2 Report structure

This report describes the complete process of the development of a design tool for The Robot Facebook. In order to get a better understanding of the context of the project, background research has been performed. This is followed by an analysis of the State of the Art to see what is already out there. This is combined in Chapter 2. Next, an user analysis is done in Chapter 3 to provide a better explanation and analysis of all the involved stakeholders. Chapter 4 describes the methods and techniques that are used within the complete design process of this product. The first phase of this method is the ideation phase which is described in Chapter 5. In this phase, multiple concepts will be developed and it ends with a preliminary final concept. This preliminary concept is further specified in Chapter 6. This specification ends with a list of requirements that the product should fulfil. The realised prototyped product will be shown and explained in Chapter 7. To see whether the product works the way it was intended and whether the requirements of Chapter 6 are fulfilled, an user evaluation is performed. This is described in Chapter 8. A complete discussion, together with the limitations and future work are provided in Chapter 9. To conclude this thesis, Chapter 10 will return to the research question stated in this chapter, and see whether a possible solution has been found. Finally, the references and appendixes of this report can be found.

2. Background research

Before starting to develop a tool for The Robot Facebook, background research has been conducted to provide a strong foundation for the entire process. Background research also helps to obtain knowledge of the context of the problem. Furthermore, looking at other related projects can serve as an inspiration for the to-be-developed tool. Within the first part of this chapter, topics of literature are explored. The second part describes the current State of the Art. Finally, a discussion is included which summarises the most important findings.

2.1 Effect of the visual appearance of social robots

The way how robots are perceived affects the user experience. Several topics on the effect of this visual appearance were researched and can be found in the upcoming sections.

2.1.1 Definition of social robot

There is an overall clear understanding of the term social robot, however, slight differences in definitions are found. One simple definition by Hegel et al. [3] states that a social robot can communicate, understand and sometimes even relate to humans in a personal way. Next to that, it should be able to understand itself and others in social terms. While this provides a good understandable basis, there are other more refined definitions. Duffy et al. provide a more philosophically supported definition of what social robots constitute, stating "*A physical entity embodied in a complex, dynamic, and social environment sufficiently empowered to behave in a manner conducive to its own goals and those of its community*" [4, p. 5]. The important element to take from this definition is the capability of a social robot to acknowledge and interact with a social environment in a coherent and expected manner.

An additional element to consider when defining social robots is discussed by Haring and Watanabe [5]. They state that humans anthropomorphize robots in order to interact with them. Meaning that humans assign human characteristics and behaviour to such robots. This is interesting to consider when talking about expectations users have of social robots based on their appearance. By combining all these elements, a definition of social robots can be formed which will be used during the remainder of this report. A social robot is a physical robot that is able to behave in an expected manner within a dynamic social environment.

2.1.2 Functionality connected to the visual appearance of robots

Social robots are expected to behave and have a certain functionality related to their visual appearance. Within complex social settings, a preference towards anthropomorphic robots is given [6]. Next to that, as supported by Haring et al. [5] social robots with a biological appearance, are expected to behave according to the behaviour of that realistic model. So a zoomorphic dog robot is initially expected to behave according to the real behaviour of dogs. While this feels rather logical for the category of zoomorphic robots, it is interesting to see how this affects other categories of robots.

It has been found that there is a preference for humanlike robots in jobs that require social skills. Goetz et al. [6] tested this theory and found a statistically significant correlation between human-like robots being preferred in social settings. This correlation is again

supported by Hegel et al. [3]. They tested which functions are connected to a social robot solely based on its appearance. This larger study by Hegel et al. found a strong correlation between visual appearance in relation with expected tasks. Human-like and functional-like robots are expected to perform more serious tasks, for example in business, research and healthcare. While animal-like robots are expected to have a function in the field of entertainment, toys and companions.

A large focus of these studies is towards anthropomorphic robots. And they barely discuss the effects of the tested theories on other categories of robots. In order to enhance the strength of the theories, more research should be performed on other categories of robots. To conclude, the conducted studies have shown that the visual appearance of a social robot is most beneficial to match the seriousness of the robot's purpose.

2.1.3 Visually dependent elements of social robots

Attractiveness is an important element in the effect of the appearance of social robots. The term attractiveness bias is introduced by psychology. Which states that people believe that attractive people possess more positive qualities than unattractive people [7]. As described by Norman [8] this effect can also be applied to objects, making it relevant for social robot design. This bias can be related to the familiarity of the user with the robot. As stated in both Hegel et. al [3] and supported by Prakash and Rogers [9], users who are more exposed to certain robots found them significantly more attractive, and likeable and are more likely to want to own such a robot.

This attractiveness bias can be connected to a well-known, but controversial hypothesis of the Uncanny Valley. This hypothesis represents the idea that robots become more appealing when they are more human-like, but only up to a certain point. Then it reaches the Uncanny Valley and a feeling of strangeness and unease is raised [10]. These unattractive objects elicit a more negative reaction, supporting the theory of attractiveness bias. Therefore when designing social robots, especially humanoid robots, it is important to account for this Uncanny Valley. To minimise the risk of a robot falling into the Uncanny Valley there are guidelines for designing a humanoid robotic head [11].

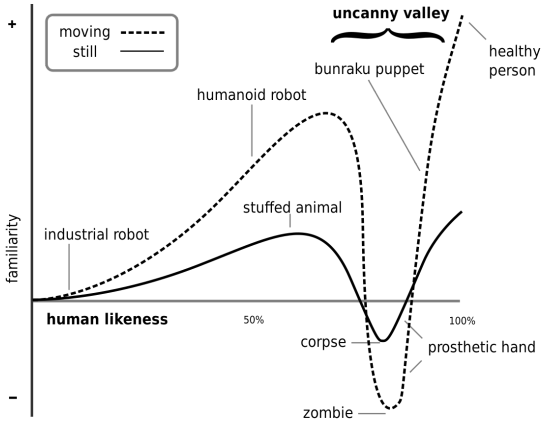


Figure 1: Visual representation of The Uncanny Valley [12]

2.2 Categorization methods of social robots

There is a large range of visual appearances of social robots. The Robot Facebook as built by Eva Velt uses five main categories of robot faces:

- **Human-like**: The robots in this category all have a face that can be described as human realistic. This includes human-realistic skin, eyes and most likely human realistic hair.
- **Anthropomorphic human**: Robots that are placed in this category have a human-like facial shape, but contain some anthropomorphic features. They tend to be perceived as humans, but aren't considered as convincing as human-like robots.
- **Cartoonish**: Robots in this category have a wide variety of forms and shapes. Their eyes are often big and prominent. Many have a funny and adorable-looking appearance. They could be considered anthropomorphic children, animals or movie characters.
- **Helmets**: Robots that are categorised in this group all have a helmet-shaped head. Most helmets contain a screen that suggests they are hiding eyes. Others have a transparent screen with visible anthropomorphic eyes under it
- **Function defines form**: This robot group varies greatly in form and shape. They are mostly abstract built, with a hint of human or animal features. Even though they don't look human-like, eyes can be identified. Most robots in this group have no type of skin coverage and show a large amount of visible technology.

To validate whether these categories are still relevant, a literature analysis is performed. Within this analysis, the question of what the main classification of social robots is is raised. Social robots can get categorised in a large number of methods. Currently, there is no general agreement on what the best or standard classification is. Every classification has its advantages and disadvantages. There are many types of classifications stated in the study of Yanco and Drury [11]. Terms such as '*task type*' and '*level of shared interaction among team*' are given as examples which can all classify robots.

2.2.1 Robot morphology classification

The Robot Facebook database is focused on facial visual aspects, and therefore the categorization should be based on appearance. This type of categorization is called morphology. The study of Fong et al. [14] is one of the fundamental studies within the field of visual appearances of social robots. Within this study, two different design approaches are described when designing a robot: a 'biologically inspired' approach and a 'functionally designed' way. Within the biologically inspired approach, the goal is to simulate or mimic the intelligence found within living creatures. For the functionally designed approach, the appearance is guided by its functionality.

Fong. et al. [14] continue by stating that there are four main categories of robots: *anthropomorphic, zoomorphic, caricatured and functional.* Anthropomorphic robots have close similarities with human characteristics. Zoomorphic imitates other living beings, such as pets. Caricatured robots have no realistic appearance but have a characteristic focal point to draw attention to that feature, such as proportionally large eyes. And at last, functional robots where their embodiment reflects the tasks the robot should perform.

In both studies by Onnasch & Roesler [15] and Yano & Drury [13], the category of caricatured/ cartoonish is being criticised. They both state that this category can not be distinctly differentiated from the others. The example of the NAO robot is taken, this robot has cartoonish features, however, it is built to somewhat resemble a human and is therefore also anthropomorphic. The same goes for a lot of animal-like robots (zoomorphic). A lot of them have cartoons-ish features, but still resemble a type of animal. See Figure 3 where Aibo ERS-7 represents a dog.

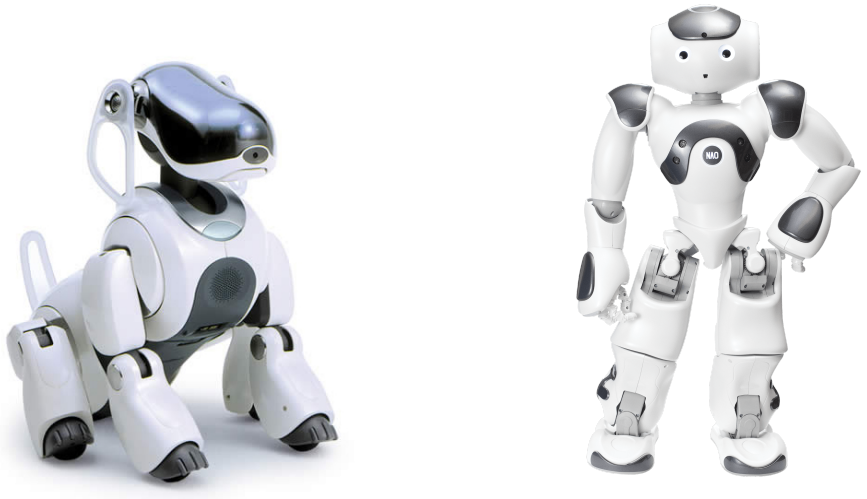


Figure 2: NAO (right) representing a cartoon-ish human [16]
Figure 3: Aibo ERS-7 (left) representing a dog [17]

2.2.2 Comparison of literature and database categories

When relating this information to the current categories of the database, multiple differences can be found. The first is the category of zoomorphic not being included. This category is used in nearly every study on the visual appearance of social robots and could be relevant to consider.

The next category is cartoonish. As previously mentioned, this category can not be seen as something completely separate and is therefore not as objective to differentiate from the others.

The following category is the category of helmets. Eva Velt [1] added this category later since a lot of robots that were found had helmet-shaped heads. However, no connection within academic studies was found to this category.

The next category is function defines form, and while having a different name in literature, namely functional, these two represent one another.

At last, within the current taxonomy, a difference between human-like and anthropomorphic is made. This difference comes down to that human-like robots are intended to look as real as possible, and within anthropomorphic humans, only human-like features are used. Robots within these two categories can be placed on a scale of human likeness. Same as in the Uncanny Valley. Take for example the robot Actriod, see Figure 4.

This human-like robot is very human-like and will therefore score high on this scale. Comparing the robot Sonny, see Figure 5, this robot will score tremendously lower on this scale, as it is also not intended to look extremely human-like. This robot could even be considered an anthropomorphic human instead of human-like within the current taxonomy. To maximise the objectiveness of the categorisation these two categories may be combined. This scale of human likeness is something to consider further along the project.

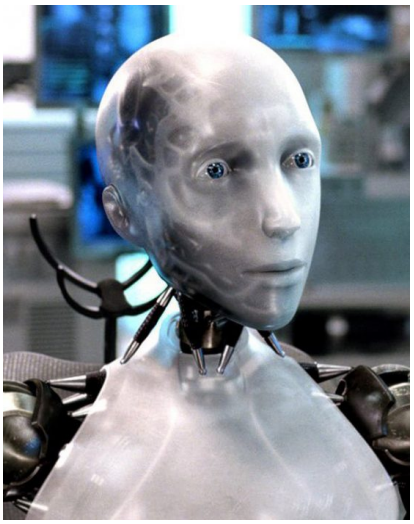


Figure 4 (left): Actroid from the Robot Facebook database [18]
Figure 5 (right): Sonny from the Robot Facebook database [19]

2.3 What are robot faces

When perceiving anything human-like, immediate attention is paid to the part where usually a face would occur. Humans are susceptible to recognising a particular pattern of features that form a face. Faces help humans to form any kind of interaction; we make assumptions and characterise anything by the looks of the face. The face is a rich and powerful source of communication. So when looking at social robots, we apply the same neurological patterns as we do to other anthropomorphic-looking objects. On one hand, humans use the face to try to understand the robot, and on the other hand, the robot's face is used to convey all kinds of cues. As stated by Chesher and Andreallo [20], the face has three distinct modes of communication: 1. Defining individual and group identity, 2. expressing emotions and affect; and 3. regulating interpersonal spatial relations. Therefore creating a face is a significant challenge since it is such a key factor in the interaction between the user and the robot.

The face of a robot consists of many dimensions. As seen in the current database, there is a large range of options when designing a new face; from rendering a face on a screen to having a physical human-like realistic appearance. Each design of a face has its own effect on the perception of the entire robot.

Next to the face, there are other modalities which a robot uses to communicate. As stated by Tsiourti et al. [21] these modalities are the face, head, body, voice and locomotion (power of moving from place to place). They stated that the accuracy of simple emotion (happiness, sadness, surprise) recognition levels were the highest through the modality of the face. However, the other modalities were also found significant in emotional recognition

accuracy. This project focuses on the design of the face, therefore the other modalities will be of lesser focus. However, they are still important to consider, also since it is still minimally researched what the relation between different modalities withholds.

2.3.1 Elements of robot faces

The face is mainly used for conveying emotions through facial expressions. And the face consists of multiple dimensions which help to express these emotions. DiSalvo [11] describes six features on robot heads which influence the perception of the robot.

1. Eyes
2. Eyelids
3. Eyebrows
4. Nose
5. Mouth
6. Ears

However, since that study only focuses on humanoid robots, other studies which describe other dimensions have been explored. Phillips et al. [22] found six facial features which characterised human-like faces:

1. Face shape
2. Eyes
3. Mouth
4. Eyelashes
5. Nose
6. Eyebrows

These two lists of features combined result in the following list of features that contribute to the expression of emotional expressiveness.

1. Eyes
    a. Eyelashes
    b. Eyelids
2. Eyebrows
3. Nose
4. Mouth
5. Ears
6. Face shape

How these features relate to one another in the perception of the robot has not been fully researched. However, the influence of each facial feature has been researched for human faces. As investigated by Diego-Mas et al. [23] facial features have a different effect on perceived facial traits which were typical of emotions. They found the following:

Feature	**Effect on perceived facial traits in %**
Eyes	23.83

Jaw (linked to facial shape)	25.73
Mouth	19
Eyebrows	13.11
Nose	12.87

Table 1: Influence of facial traits in percentage

The feature of ears has not been found statistically significant in the achievement of facial expression in humans. However as stated by Doroftei et al. [24], ears are important in robot ears, just as in animal ears. Ears can emphasise certain expressions. Take for example a zoomorphic dog robot. The ears can contribute to the expression of fear or sadness when the ears are oriented to the rear of the head. Therefore ears are included in this study.

2.3.2 Movement in robot faces

Robot faces are dynamic objects. So not only the appearance of certain features influences the perception, but how they move is also an important factor [25]. For example, when the robot follows the user with its eyes, a more human-like experience is obtained. Therefore, other human-like behaviour is expected from the robot [26]. Separate parts of the face have different influences on facial expression. So is the mouth of higher influence for the emotion of happiness, since that is more easily recognized by smiling.

Through the movement of features, expression is created. When analysing the movement of the face during facial expressions in humans, several dimensions can be differentiated. In general four types of movement for expression can be found [27]:

1. Eye operation
2. Eyebrows movement
3. Jaw & mouth operation
4. Movement of the entire head

The first element of expression that is on the list is eye operation. Eye operation is very influential on the perception of the robot. The way the eyes are operated in a robot sets a lot of expectations. The complexity of the eye operation has a lot of impact on how the robot is perceived. The second feature that is often connected to the operation of the eyes, is the movement of the eyebrows. Eyebrows can make a big contribution to the expression of several facial expressions. As previously mentioned, ears are also influential in this perception. Often the operation of the ears is connected to the eyebrows. The third operation is the movement of the jaw and mouth. These two directly influence one another and are therefore categorised under one operation. Lastly, is the movement of the entire head. And while this is not directly connected to facial expression, it influences the way how the robot is perceived, for example through the tilting of the head. If the head moves during communication, it will be perceived as more human-like. Since the face of a robot is a

dynamic feature, the complexity of the movement of these features should be considered when designing a new face.

2.4 How to design better

The goal of the tool for The Robot Facebook is to eventually help designers with making better robot faces. Therefore it is good to know how designers come to better work. When knowing what techniques positively impact designers, it can be taken into consideration and incorporated into the to-be-developed tool. And while these techniques may differ from person to person, some general ways could help. Within the following section, multiple ways have been discussed that help regarding the domain of design.

2.4.1 Be/ stay inspired

One of the most recurring suggestions on how to make better design comes down to becoming and staying inspired. Inspiration serves as a crucial factor in creativity. And while inspiration may come from every direction and is something very personal, some general ways help trigger this. One way is to surround yourself with good design. This could trigger new ideas. Great examples can be found online and in real life. When confronted with great work, you automatically take inspiration from it and apply it to another project [28].

2.4.2 Collaboration

Creativity is something that can be combined with others. When working together on projects, you automatically build on what others are saying. The thought of one person could trigger something within someone else, which may result in a thought that otherwise never would have occurred. However, these thoughts must be effectively communicated. Otherwise, scenarios may occur where one designer may say something while implying something else. And this could result in ineffective outcomes [29].

2.4.3 Staying educated

The domain of design is a highly academically researched field. There are many scientifically proven theories and methods that help designers make better designs. Since a large group of designers not only works on one specific topic, such as robot faces, it is hard to keep up with all the current research. Therefore before starting a project, it would be advisable to perform some research about the specific domain. See what research has been done within that domain, and look at how this can be applied within the provided project [29].

2.5 Design tool types

To eventually come to a practical solution, often a list of ideas is thought of and discussed. It is very unlikely that the first idea becomes the final product. Activities such as brainstorming help produce multiple ideas. During these activities, one could use certain tools and methods to boost creative thinking which could help to come to good solutions.

Within the following section, multiple types of design tools are discussed to eventually see which tools could be a potential match for this project. It is important to note

that there are more design tool types than the ones described, however, the ones described are seen as a higher potential match.

2.5.1 Gamification

Board games have been developed that help boost creative thinking within a collaborative scene. The study of Alenquer and Gan [30] developed a board game that a team could play to come up with more creative ideas. This board was developed as a replacement for a standard brainstorming session. It lets participants create scenarios from different approaches and pitch them to the team. For example, one task is to create a scenario pretending to be in the shoes of the consumer. New good ideas are rewarded and repeated ideas are eliminated.

This example of a board game is an effective way for users to come up with more creative ideas. It makes use of the theory behind gamification. Gamification is a strategy that can help increase engagement and happiness and eventually to solve problems effectively [31]. One downside to this type of design tool is that it can only be played with multiple people. It becomes way less effective when played within a small team of for example two people.

Figure 6: Board game by Alenquer and Gan [30]

2.5.2 Card-based design

Card-based design tools are cards that are similar to regular playing cards but help with designing. Such cards have been around for quite some time. One of the earliest examples is The House of Cards created in 1952. These cards were made to stimulate innovative thinking. There are different types of cards, some have simple tasks such as 'Do the last thing first'. Other types of cards have for example more information on them. An example of those cards is the IDEO Methods Cards. The cards describe one method and include some brief information about how and when to use that method. Different types of cards can be used among different parts of the design process; some are better for evaluating, while others are better for brainstorming [32].

As stated by Carneiro et al. [33], having card decks as a design tool helps to make external representations. They help organise the information into tangible blocks. By having the information spread out in relatively small quantities, it helps apply the information to a new context. They help present theoretical constructs and make them more playful. It is proven to be an effective tool in converting theory to practice. They encourage discussion and

creative dialogue. One downfall of this design tool is that they are static. Cards lack the ability to update, and most of the time are also limited in dynamic interaction.

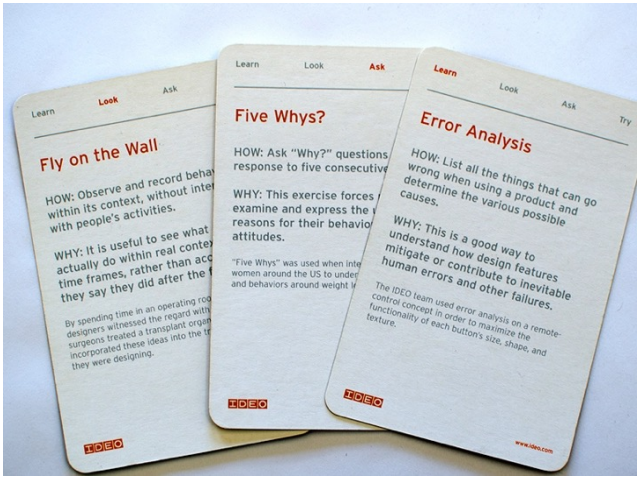


Figure 7: IDEO Methods Cards [32]

2.5.3 Mind mapping

As well defined in the study of Zahedi and Heaton mind mapping: "*... involves the graphical representation and visualization of connections between several ideas or pieces of information*" [34, p. 3]. It is used as a tool that helps make connections between terms and ideas, raising new possible ideas. As in the card-based design, a mind map helps represent the information in a more tangible visualisation. This visualisation helps designers break up their thoughts into smaller pieces, pieces that later can be connected in unique ways. Often when creating a mind map the concept or problem is stated in the middle, and then associated ideas are connected to this problem.

While this method does not contain any domain-specific information, it is an interesting potential tool for The Robot Facebook, hence being included within this section.

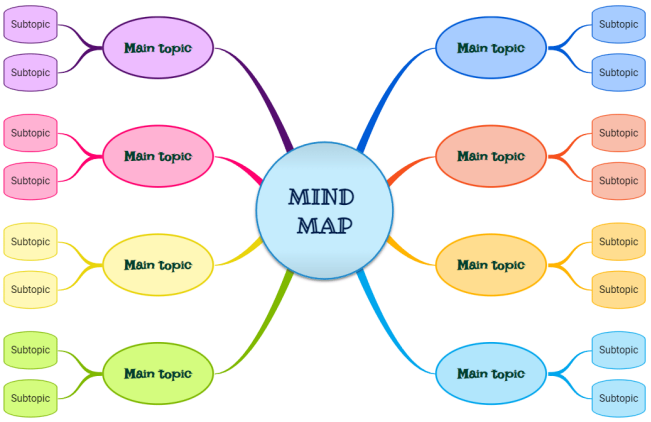


Figure 8: Mind map structure [35]

2.6 Copyright concerns

The Robot Facebook database is currently published on a website [2]. The database makes use of data from other publishers. And normally when the source is referenced, copyright does not raise the biggest concerns, especially since it's a smaller non-profit project. However, after publishing the database in 2017, one case caused problems due to copyright concerns: the CB2 robot from Robotics Today B.V. This robot was not allowed to be publicly listed on a database without permission [36]. To eliminate the chance of this happening again, database rights have been looked into. There are two different types of rights when dealing with such a project. The first part deals with copyright concerns, so concerns about the material that is used. And the other part deals with database rights, so the rights The Robot Facebook itself has.

2.6.1 Copyright concerns

The European Union has set up a framework on the free flow of non-personal data which ensures the free movement of non-personal data [37]. This allows data unless stated otherwise, to get reused in other datasets. This implies that when no information is granted on how to deal with copyright concerns within the project, it is allowed to restore the data in another database. Another licence a project could have are the licences of Creative Commons [38]. Most of these licences are used to indicate that it is allowed to redistribute that data. There are different layers of these licences. When dealing with a new robot case that has a Creative Commons licence, it should then be looked into what that specific licence entails.

Many websites contain a legal page where copyright concerns are dealt with. Take for example the robot Kasper from the University of Hertfordshire. They stated the following: "*Subject to the provisions below, you may view, download and print any pages from the Website for your own personal non-commercial use only.*" [39]. This is quite a standard statement on copyright concerns. These regulations make it hard for The Robot Facebook to be used for commercial purposes. If wanted to use as a commercial end, every singular robot should be gone over to find out the copyright regulations and be removed if not allowed.

When adding new robots within the database, the copyright concerns of that specific case should be looked at. This will prevent a similar case as the CB2 robot from happening again.

2.6.2 Database rights

When a database fulfils certain requirements set up by the European Union, the contents of the database are protected. A database is formulated as a "*collection of independent works, data or other materials arranged in a systematic or methodical way and individually accessible by electronic or other means.*" [40]. If the maker of the database can show that there has been substantial investment (financial, material and/or human) made into the database, it falls under the Sui generis protection rules. This allows the prevention of extraction and/or reuse of the content of the database. This is granted for 15 years from the first creation date.

The Robot Facebook falls under this Sui generis protection and therefore is automatically granted this protection. The first creation was made in 2016, and therefore this

protection will be granted till 2031. This entails that when the database gets reused, it makes it possible for the creator to not permit this. And while this currently may not be most relevant, it is good to keep it in consideration for future work if the project is continued.

2.7 State of the Art

Within the following section, five related projects are described. Most of them use methods as described in Section 2.4. These projects were found by either searching for related projects within the field of robot design, or by searching for examples of design tools.

2.7.1 DSD cards

The D4CR (Designing for Children's Rights) institute has developed a set of cards that serve as a design tool, named 'Developmentally situated design' (DSD). They implemented the methods and techniques of card-based as explained in Section 2.4.2. The tools have information about the cognitive, physical, social and emotional abilities of children on them. Since there is so much information available on designing specifically for children, it is nearly impossible for designers to remember nearly all the information. Therefore D4CR felt it would be useful to develop cards to make this conceptual information more accessible. The cards can be used at multiple stages of the design process, such as in brainstorming to inspire, as heuristics, but also as guidelines when creating personas. The cards were positively received within multiple user design exercises and seen as effective within the design for children domain [41].

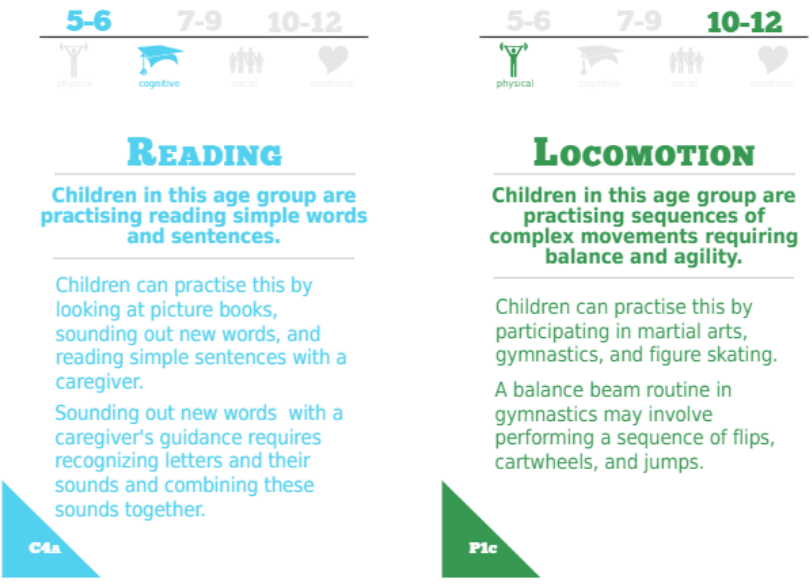


Figure 9: The DSD cards developed by D4CR [41]

2.7.2 CoCoCo toolkit

As a graduation project, Suhaib Aslam and Jelle van Dijk have developed a design toolkit that helps autistic adults co-design collaborative robots. The Co3 toolkit can be used as a

linking bridge between the eventual target audience and the designer. The tool makes use of a card-based design together with some aspects of mind mapping. It contains cards with robot features on them, which can be linked together on a table through a sort of mind-mapping technique. It allows autistic participants to lay out the features of the robot in a structured manner. This way a fluent workflow between the 'blueprint' of the robot and the prototype is created. The kit was positively received and projects the participants and is a promising framework in the collaborative design domain [42].

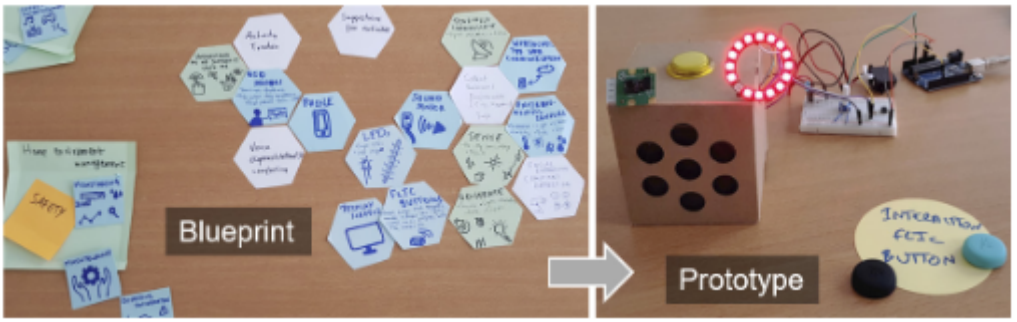


Figure 10: Workflow of the CoCoCo toolkit [42]

2.7.3 Tiles for the Internet of Things

The Internet of Things (IoT) offers a large set of opportunities within future technology. Mora et al. [43] developed Tiles Cards which help understand and apply the concepts of IoT. It consists of a set of 110 design cards and is aimed to support and trigger creative thinking, offer criteria to evaluate ideas and help suggest a set of possible technologies. There are 5 types of deck cards: things, human actions, feedback, connectors and data channels. Each card deck has different goals. When combined it opens the opportunity for interesting scenarios of idea generation. The Tiles come along with a so-called playbook and cardboard, see Figure 11. The cardboard helps provide more structure during the workshops. And the playbook helps guide the users step-by-step during the ideation process. The Tiles were proven to be effective in supporting design and idea generation for the IoT.

Figure 11: Cards and cardboard design of the Tiles for the Internet of Things [43]

2.7.4 It Is Your Turn: Co-creative robot through sketch

It Is Your Turn is a project in which an AI mobile robot named Cobbie was developed that is used for sketching ideas. The idea is that the user first sketches their idea on paper, then Cobbie analyses this drawing and sketches a new drawing based on the previous sketch. The user can take inspiration from Cobbies work and continue drawing new ideas based on this AI-made sketch. This method is based on the idea of co-creativity. Normally this combines the creativity of multiple humans, but in this project one human is replaced by a robot, offering new opportunities for ideas. Results of the user evaluation show that Cobbie effectively inspires participants. Helping them come up with ideas that otherwise never would have happened [44].

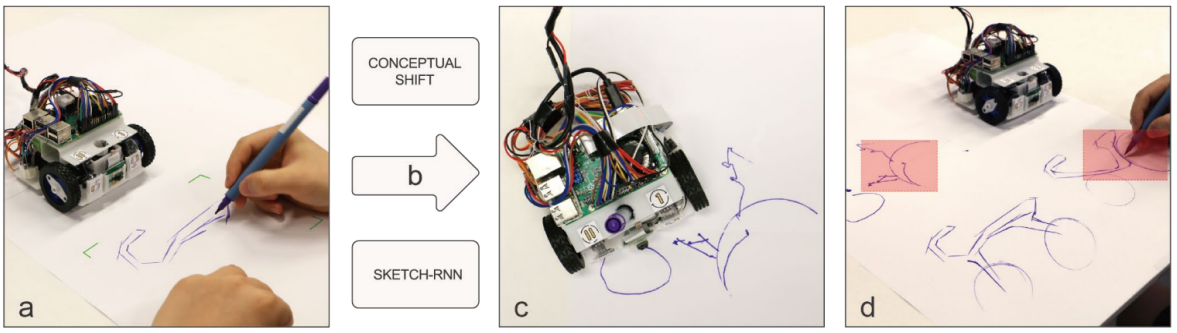


Figure 12: Workflow of the It Is Your Turn project [44]

2.7.5 PRECISION effect Wild Cards

The Wildcards of Precision Effect is a mobile app which shows 38 cards that offer a jumpstart to creativity & innovation. The cards have interesting tasks and methods on them that could help for example during a meeting. They promote the app as a way to use creative techniques to jumpstart or improve brainstorming that can be used in the moment. Two examples of the cards are shown in Figure 13 [45].

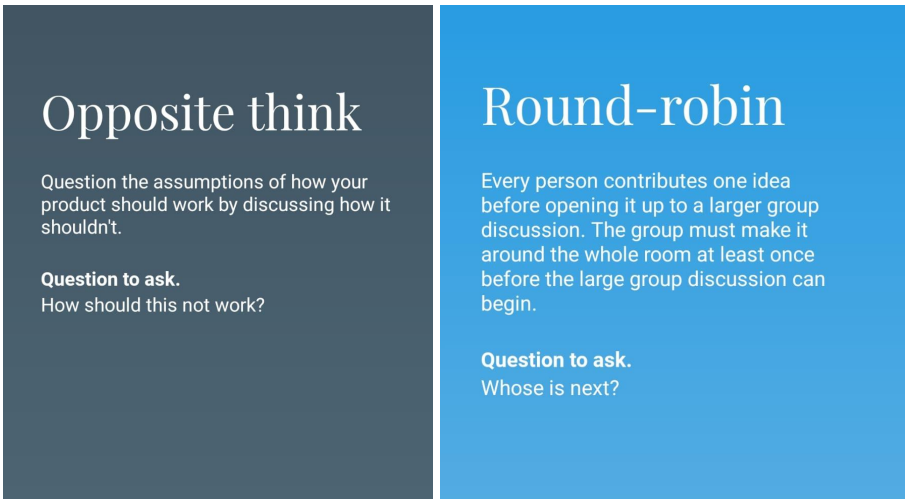


Figure 13: Two example cards of the Precisioneffect Wildcards [45]

2.8 Discussion

The background research has provided a lot of useful insights that help in the process of developing a new tool. Literature helped to show the effect of visual appearance on social robots. Next to that, categorisation methods are explored, which leads to a different method than the one currently used in the database. A lot of insight is gained from exploring design tool types, which are in relation to the current State of the Art. These sections helped to form the inspiration for the project. The most important findings from the literature and the State of the Art are taken into account in the following chapters.

3. User analysis

To get a better understanding of the users and other stakeholders for this project, a user analysis is performed. First, a stakeholder analysis will be completed. This helps to see which groups are relevant stakeholders. This analysis continues by making a power influence graph to see how influential each stakeholder is. This graph places all the involved parties that have 'influence' and 'interest' as their axis. When having identified all the stakeholders, it is important to get to know them. This is done by performing three expert interviews. When eventually having all stakeholders laid out together with their needs and values, a list of preliminary requirements is set up.

3.1 Stakeholder analysis

To design something for your target audience, it is important to know the involved stakeholders of the project. This way you can ensure the product satisfies the actual needs and requirements of important stakeholders [46]. A stakeholder analysis will help gain insight into who these stakeholders are and how important they are. First, a stakeholder identification is performed, and later a power/interest graph is made that places these stakeholders in a field of influence.

3.1.1 Stakeholder identification

The stakeholders of The Robot Facebook tool consist of four groups. The first stakeholder is the client who administers the current database. The second is the developer of the tool. And the last groups consist of two groups of end users: users with knowledge of facial robot design, and users without this knowledge.

Most of these end-users will be designers. This group has the most interest in having a tool since it would make this process easier. The group with knowledge and the group without might experience and expect other things from the tool. By clearly stating what both of these groups want and need, it will be more likely to be taken into consideration in the final product.

Another stakeholder is the client who provided this assignment and is also currently administering the database. For this project, this is the supervisor Edwin Dertien together with Robby van Delden. They help the developer by providing structure and guidance throughout the process.

At the last, the final stakeholder is the developer of the tool itself. It is up to them how they interpret all the requirements and needs of the other stakeholders.

3.1.2 Stakeholder analysis

A stakeholder analysis helps to understand the involved stakeholder, and what their part is in the development process. It gives a clear image of their interests and influence. To help visualise this, a power influence graph is made, which can be seen in Figure 14. The x-axis represents the interest, and the y-axis the influence. The numbers placed in the graph represent all the identified stakeholders.

1. Designers without prior knowledge
2. Designers with prior knowledge
3. Client who administers database
4. The developer

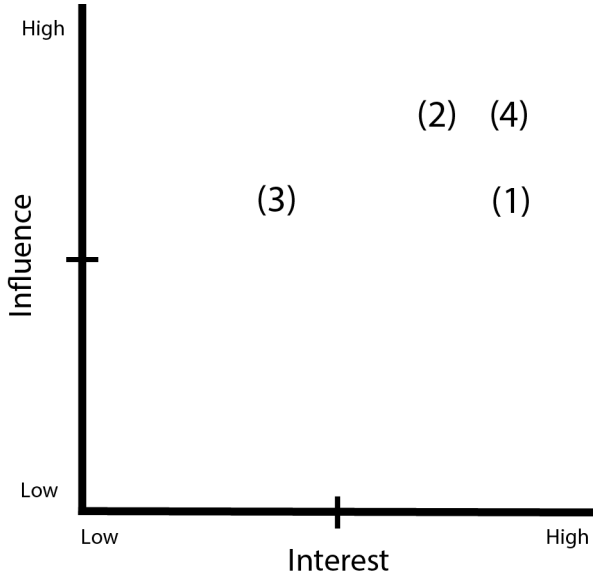


Figure 14: Power influence graph of identified stakeholders

Both types of users have a high interest in the to-be-developed tool. However, a slight difference in influence can be noted. Designers who have prior knowledge in the domain of facial robot design (2) have a better understanding of where normally the struggle points within this process lay. Therefore they know best where and how this tool should function. This places them slightly higher on the scale of influence.

However, this does not imply that the other part of the target group (1) is not of importance. They may have less experience in that domain, however, this also places them higher on a scale of interest. This tool could potentially guide them through the design process, which is very interesting for them.

The client who administers the database and provides the assignment (3) should be kept satisfied, and their advice should be seriously considered. However, they are not the target audience for which this tool will be developed, placing them lower on the scale of interest.

Since the developer (4) makes the tool and considers whether all requirements are met, they place high on the level of interest and influence.

3.2 Expert opinion

In order to get a better understanding of the requirements for the tool, experts in the field of social robot design and or who are familiar with other design tools were asked for an interview. In total three different interviews have been performed. The goal of these interviews was to see in which part of the design process the tool would be most relevant. The interview was semi-structured, meaning having a list of questions prepared but leaving

space for the conversation to take some off–script directions. Some questions were asked about how different designers deal with the design process. Then questions which were more specific on how such a tool should serve its purpose and what information it should contain were asked. The transcription of the interview can be found in Appendix B.

3.2.1 Interview #1

The first interviewee considered design tools as something helpful and efficient in the process of coming up with ideas. One thing they found worth mentioning is the value of actively involving the final user in the design process. This helps to check whether the established requirements of the users are part of the product. However, they do find it sometimes hard to talk with other stakeholders. These other stakeholders often say something they want or need something, while actually implying something else. A tool that helps assist with this communication would be helpful.

When asking questions about the to-be-developed tool the interviewee made a statement about the current broad range of options. At the start, this makes it hard to narrow down parts of the design: "*There are so many options to consider, options in shape, size, colour and a lot more. Seeing what is already done for a certain user group, and why they did that will be very helpful.*" This implies developing a tool that compares the current State of the Art with the requirements for a new project. Having such a tool makes it visual what kind of robot face works and why that works.

3.2.2 Interview #2

The second interview went in the direction of using the tool to facilitate a design space for facial robot design. Design space is a space which serves as the basis for creative teamwork and is used to work on a project, develop ideas, etc. They said the tool would then need to provide all the parameters for facial robot design. This would help to provide an overview of all the possible options and combinations. They also stated that splitting up a design problem into small components helps comprehend all the information. Next to that, by breaking it up into small chunks interesting combinations can be made that help trigger creative thoughts. The interviewee also mentioned the relevance of linking the current knowledge to the related work. Apart from that, they said that the tool would be helpful if it could bridge the gap between the designer and the stakeholder. For example by having the option to use the tool in a conversation with a stakeholder to explain certain decisions.

3.2.3 Interview #3

The third interviewee again valued the use of design tools during the design process. They said that since there is so much domain-specific information available, it is sometimes hard to filter which sources are relevant. Sometimes the process of searching for guidelines or heuristics for a specific domain, such as robot design is very lengthy. By having a tool that summarises all this information, it becomes a lot easier and quicker to make design decisions. Next to that, they stated the flexibility of the tool would be something worth considering. Implying not only developing a tool for a small part of the design process but allowing the options to use the tool in multiple parts of the process.

3.3 Preliminary requirements

When combining all information and knowledge that has been collected so far, a list of preliminary requirements can be made. This list helps provide guidance for the next phase of ideation. A category is placed next to the requirement to understand where that requirement originates from.

Nr.	**Requirement**	**Category**
1	Should help designers make better robot faces	Client
2	Should help designers stay or become inspired	Background research
3	Should provide guiding design information	Background research & Interviews
4	Should make use of logical categories of robot faces	Background research
5	Copyright should not be of concern	Background research
6	Should be flexible in use	Interview
7	Should display the current State of the Art	Interview
8	Should serve as a design space	Interview
9	Should divide information into small comprehensible components	Interview
10	Information should be structured consistently	Interview
11	It should help designers support and explain their decisions to stakeholders	Interview

Table 2: Preliminary requirements

4. Methods and Techniques

The process of developing a tool for The Robot Facebook is followed through the Creative Technology Design method created by Mader and Eggink [47], see Figure 15. This approach helps provide a structured workflow within design projects. It is divided into four phases: ideation, specification, realisation and evaluation. This approach helps combine the knowledge gained from literature with feedback from the actual user. This way you ensure you design for the user's needs and requirements. Cyclic loops within the process allow returning to previous stages when elements change or new knowledge is obtained and to make iterations to the product. Since this project continues from an older project, alterations to the process were made where seen fit.

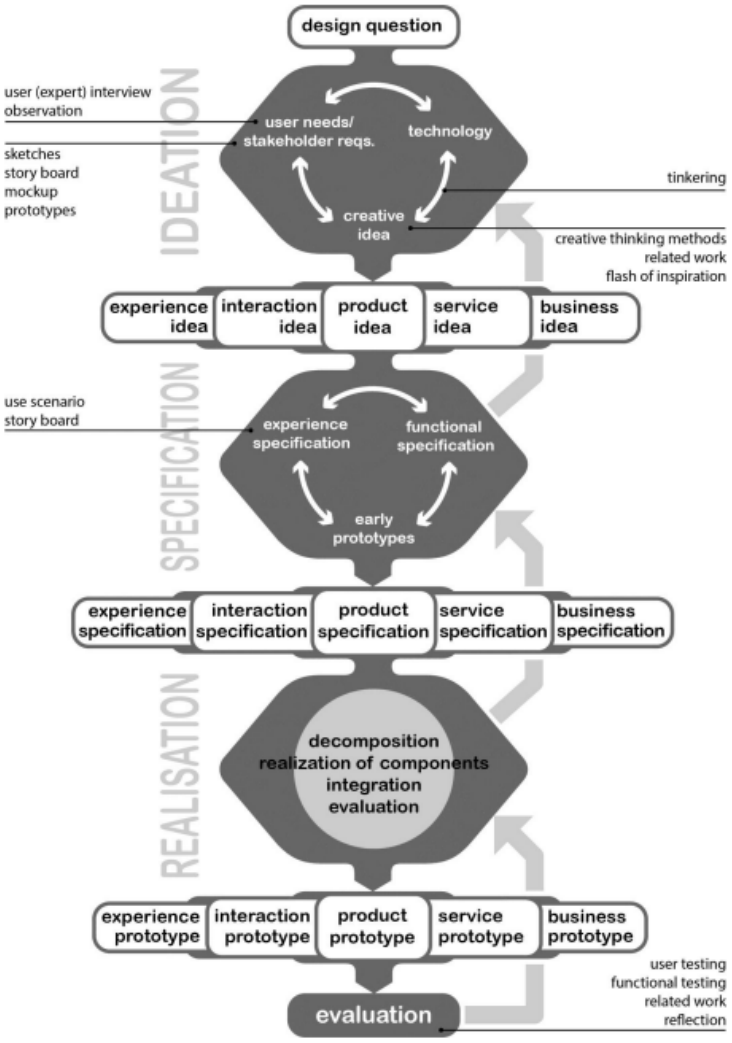


Figure 15: The Creative Technology design process [47]

4.1 Ideation

The first part of the Creative Technology design process is the ideation phase. Several concepts will be generated within this phase. And in order to come up with various concepts

for the tool, multiple brainstorms were held. In these brainstorming sessions, the needs and values of the most important stakeholder were taken into consideration. This is done by constantly referring back to the preliminary requirements.

Three different brainstorming sessions with different goals were held to finalise a concept. The first session was a preliminary brainstorming session. This session was performed before setting up the list of requirements and talking to experts. The goal of this brainstorming was to see where natural problems would occur and which type of tools would help to solve this. It was done together with a fellow student who is not directly involved in this project but is familiar with other design tools.

The second session of brainstorming was used to think about the functionality of the tool. For this, the input from the expert interviews was taken into consideration. The different answers from the interview help determine in which part of the design a tool would be considered relevant.

The final brainstorming session was held in order to come up with the content of the previously developed concepts. This session helped to realise potential problems, and how to prevent or solve them. The results of this session will be taken into the next phase. Together these three brainstorming sessions formed the basis of the concept generation.

4.2 Specification

The goal of the specification phase lies in finalising the requirements for the end product. The preliminary requirements that were created within a previous chapter serve as a starting point for these requirements. To further expand the knowledge of the interaction of the tool, personas and scenarios were created in which the final concept described in the ideation phase is used. This phase ends with setting up a list of functional & non-functional requirements for the tool. These requirements are prioritised with the MoSCoW method.

4.3 Realisation

Using the preliminary requirements of the specification phase and the final concept of the ideation phase, the realisation can start. The requirements serve as guidelines for making the actual product. Several iterations were made which eventually come together as a Hi-Fi prototype.

4.4 Evaluation

The final phase of the Creative Technology Design method is the evaluation phase. The goal of this phase is to test the developed product with the target audience to see whether the requirements were met. The evaluation consists of two parts, an interaction with the product and an interview. After obtaining results from this test, an actual evaluation is performed. This way the researcher can know what parts of the tool need some alterations.

5. Ideation

The ideation phase is the starting point in which new ideas and concepts are introduced. Followed by the gained knowledge from the previous chapters, several brainstorming sessions are performed. The list of preliminary requirements forms a fundamental starting point for these sessions. Several steps were taken to develop multiple concepts. In total three brainstorming sessions were performed, each with a different goal. The following chapter shows the results of these sessions and ends with a discussion to see which concepts are worth considering for the next phase, to eventually present the final concept.

5.1 Pre-requirements brainstorm

The first brainstorming session was performed before doing expert interviews and setting up the preliminary requirement list. This decision was made in order for the designer to see where they thought problems would naturally occur in the process of facial robot design. This initial problem recognition was used during the expert interviews to be able to ask more in-depth questions. Second, it helps to start the problem-solving process in which inspiration is constantly taken from other projects. Last, it helped to not to feel restricted by any requirements, making it, therefore, easier to come up with more out-of-the-box ideas.

This brainstorming session was performed together with another designer who is not actively involved in this project. First, a general description of The Robot Facebook was given to that student, together with the most important findings of the literature research. By brainstorming in a pair, it helped to be able to bounce ideas off one another. All the concepts were first drawn on a whiteboard, and later individually elaborated on. In total, three concepts were thought of during the brainstorming session.

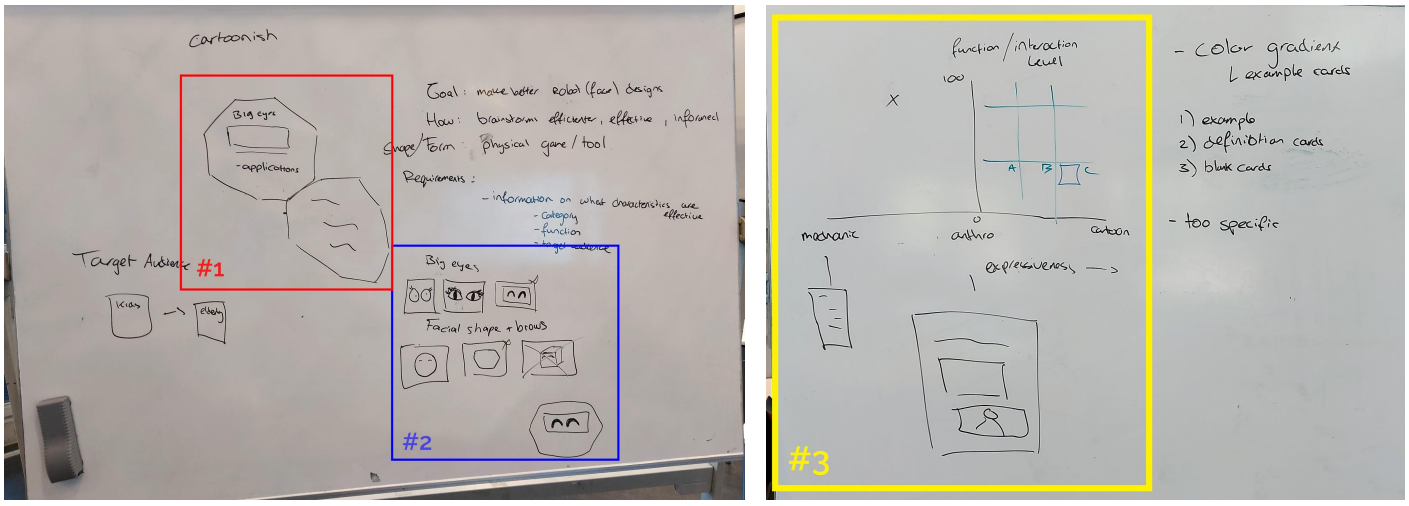


Figure 16: Ideation concepts #1, #2 (left) and #3 (right) made in pre-requirements brainstorm

5.1.1 Concept #1 Hexagon design cards

The first concept makes use of a card-based design. It includes hexagonal-shaped cards that contain elements of a face design for a social robot. In the centre, a base card is placed. These base cards represent one of the main categories of robots: *anthropomorphic, zoomorphic and function defines form* (or the current main categorization terms). On this card, an

example is shown together with a description of what that type of robot is most often used for. Next to these base cards, attribute cards can be attached. These contain a specific feature of a robot's face, such as big eyes. On the flip side of these cards, more information can be found of that feature together with relevant sources.

These cards can be used to lay out all the features that a new robot will consist of. It helps to see all the possible options and the information about why that feature is used. This concept tool can for example be used in a brainstorming session.

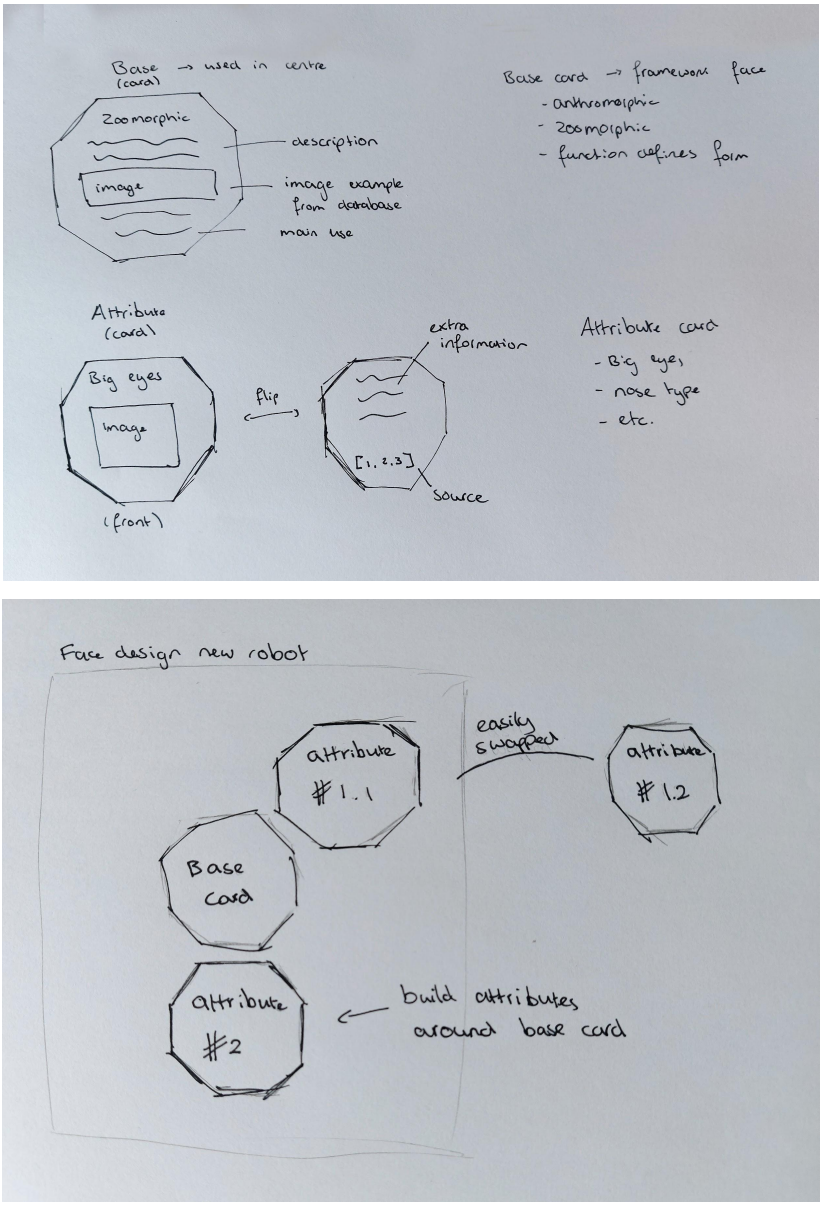


Figure 17: Ideation concept #1 drawn on paper

5.1.2 Concept #2 Hexagon design cards - detail specific

The second concept is somewhat of an extension of concept #1. During the making of concept #1, the comment was made that it would be relevant to see more detailed and real-world options of the attributes. So take for example the feature of big eyes. As seen in Figure 18, this concept would show you all kinds of available options that are within the

database, compared to only showing the general type. A more informed decision could then be made about what kind of big eyes you would want in your design. A little checkbox would help to see which attributes you have selected. So when you combine all the examples of the attributes, you can compose your robot face.

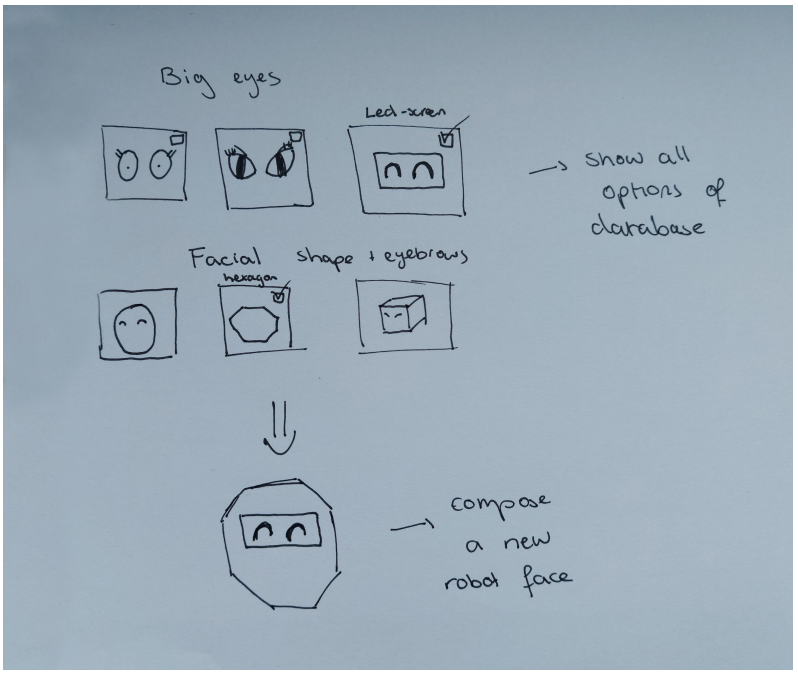


Figure 18: Ideation concept #2 drawn on paper

5.1.2 Concept #3 Evaluation graph

The third concept is aimed at being an evaluation tool. It consists of two parts: the design evaluation field and the robot cards. The evaluation field is a graph in which the x-axis represents expressiveness, and the y-axis functionality/interaction level. The expressiveness axis has at the left side mechanic robot faces. So robots with a very low level of expressiveness. On the right side are cartoonish robots, so robots with a high level of expressiveness. In the middle, anthropomorphic is placed. The y-axis is divided by function/ interaction level and is expressed in percentages. How higher this percentage is, how higher the functionality of the robot is. So in general, the higher this percentage, the more complex the robot is.

Cards of robots in the database can be placed within this field. This helps designers understand what expressiveness implies, and how this affects the robot. It forces them to think about this topic. Blank cards are provided on which designers can draw their robots and then place them somewhere in the field. This helps them to better understand the decisions they made about the design. It can also be used as an evaluation method to see whether the requirements of the design are met.

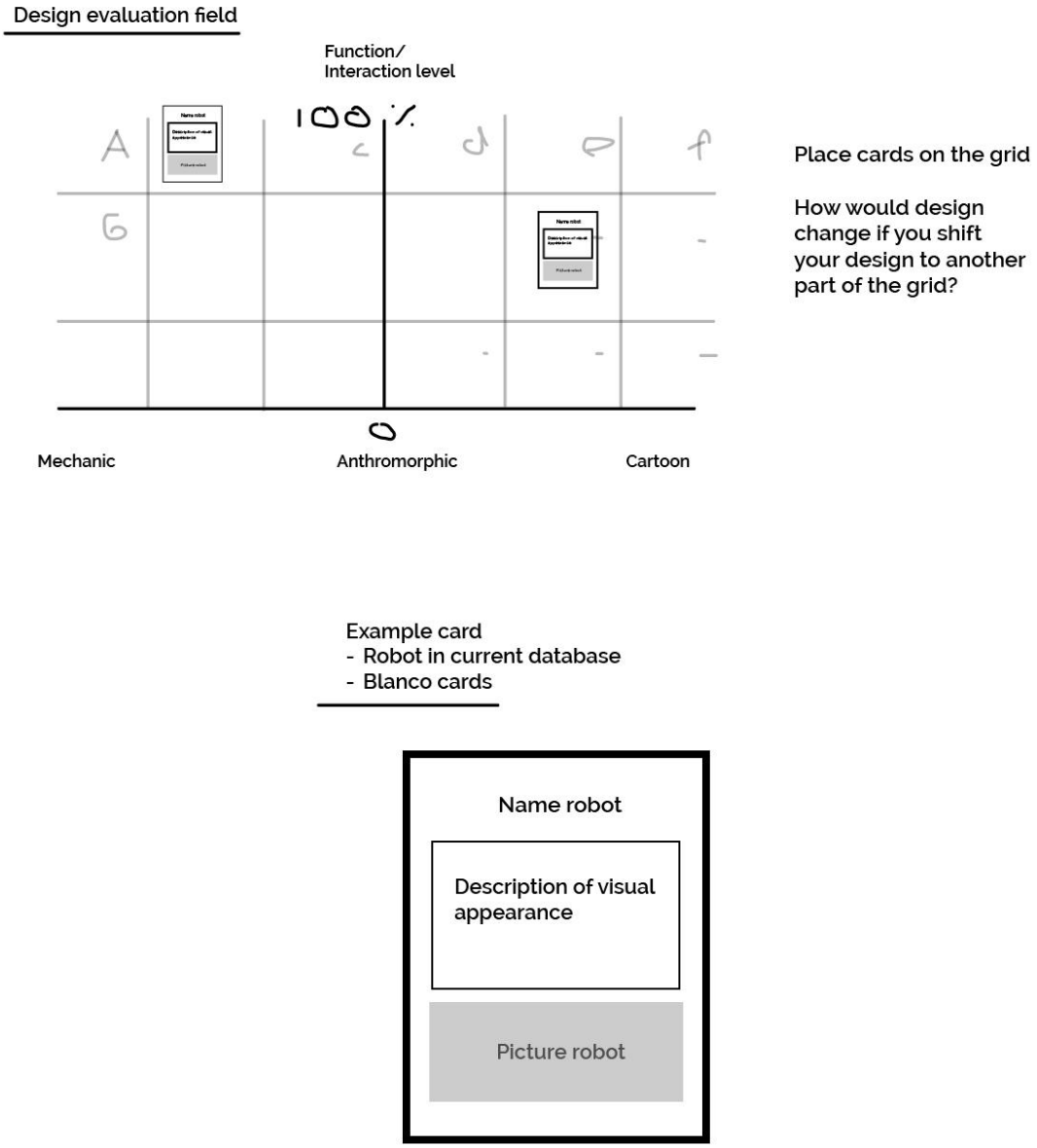


Figure 19: Ideation concept #3 Evaluation graph digitally drawn

5.2 Functionality brainstorm

The second brainstorming session was held after creating the preliminary requirements of Section 3.3. This helped create a more informed brainstorming session. The previously created concepts were taken into consideration and formed as a source of inspiration. The goal of this session was to think of the functionality of the tool. During this session, one larger concept was worked on which consists of smaller elements. Initially, this concept was drawn on paper, however, all the elements were eventually worked out digitally. These elements are in the following section separately explained.

5.2.1 Framework cards

This concept is based on a card-based design. As explained in Section 2.4.2, a card-based design helps break up large amounts of information. Next to that, it creates the possibility to make interesting combinations of cards, which help trigger creative situations. The first part of this concept consists of large Framework cards. These cards contain the framework of one of the main categories, so for example anthropomorphic. On the flip side of these cards, a description of that framework is given together with some applications of that type of robot face. Next to that, related examples are shown which are taken from the current database.

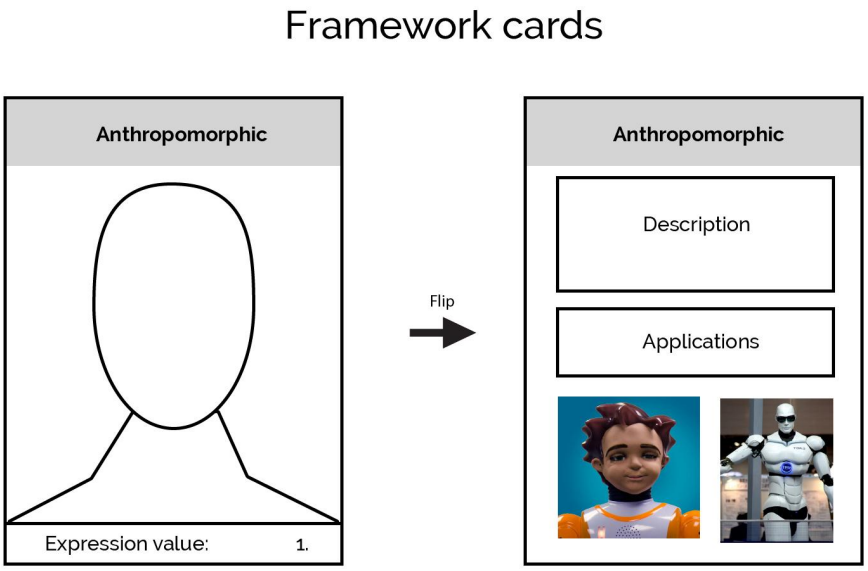


Figure 20: Framework card of Anthropomorphic facial shape

5.2.2 Feature cards

The second part of this concept is the Feature cards. These cards contain a specific detail of the face of the robot, so for example the type of eyes. The card in Figure 21 takes the example of human realistic eyes. There will be several categories of Feature cards such as eyes, mouths, ears, etc. These Feature cards are a lot smaller in size compared to the Framework cards. The idea of these cards is that you can detach the drawing of that feature, and reattach them to the Framework cards. This allows users to get an overview of the design of the robot. These Feature cards contain information on in which context that feature is most often used,

and what the effect of that feature is. The backside of these cards contains examples from the database, and there is the possibility to show some extra information.

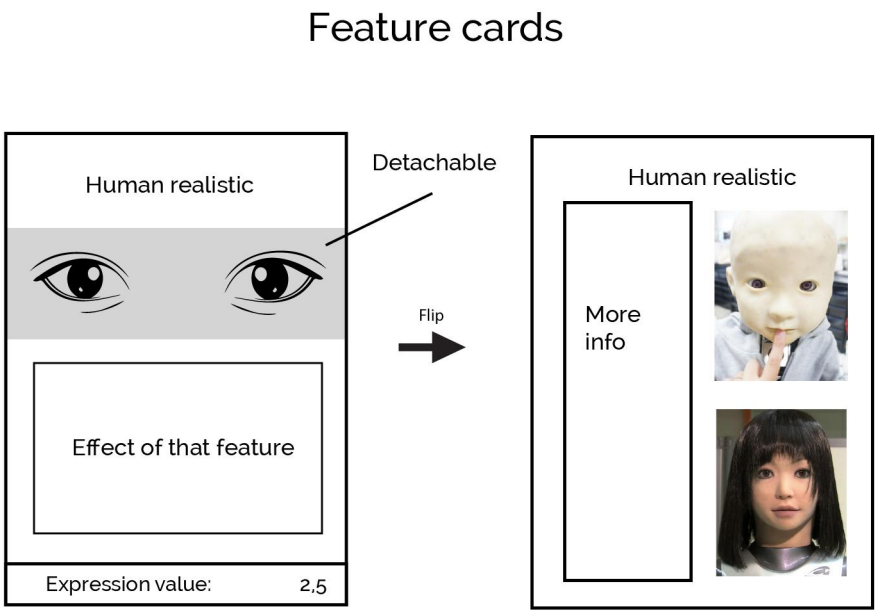


Figure 21: Feature cards of human realistic eyes

5.2.3 Expression value

The last part of this concept is the expression value. Expression is the ability to convey emotions [22]. Most anthropomorphic robots' faces can do this well, while mechanical robots most often don't. For example, Alice and Ameca are way better at making facial expressions compared to Chimp and Hermes, see Figure 22 for all robots respectively.

In some scenarios, a high ability of expression is preferred. For example, robots that are used as companionship for elders. While in other scenarios, low ability of expressiveness is better. Take for example robots for the military and security. The presence and type of features determine whether that robot can show emotions effectively. In general, lifelike features are better at conveying emotions. So human-realistic eyes and mouths help tremendously for people to recognize expressions, and therefore create a higher expression value for that robot.

In order to inform the user about this level of expression, a newly created value can be attached to features - a so-called expression value. Every feature and framework would have a level of expression, and the total expression can be determined when adding all values. A formula will take all values from the cards into consideration and calculate a total. This scale of expressiveness should be connected to the consequences of such a level of expressiveness. This way designers can make more informed decisions about whether they want features that have the ability to convey emotions or not. And while the absolute value of this formula does not have a true meaning, the comparison between the values is what is of importance. When for example switching the type of mouth, and seeing how this affects the expression value is relevant to know.

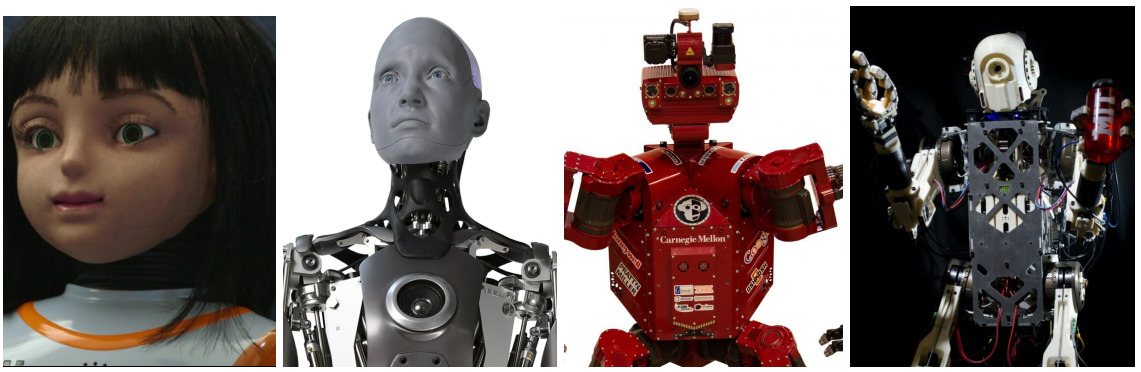


Figure 22: Anthropomorphic robot Alice, Ameca and mechanical robot Chimp and Hermes respectively [48]–[51]

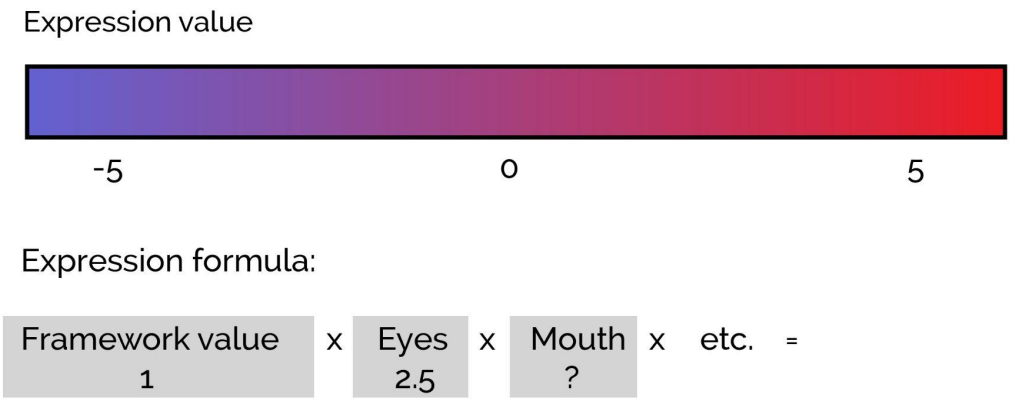


Figure 23: Concept Expression value

5.3 Content brainstorm

The goal of this final brainstorming session was to dive deeper into the content and details of the tool. This brainstorm continues to build on the concept of the previous session; the Framework and Feature cards in combination with the expression value. However, within this brainstorm, some new elements were developed, and are therefore included in this section.

5.3.1 Action cards

Action cards are an additional stack of cards that have small tasks on them. These tasks are challenges that help motivate the user to think in a certain direction or help trigger new creative thoughts. An example of an action card would be: take a random eye Feature card. This helps the designer to make new combinations which otherwise would not have occurred. Another interesting action card is to let the user draw a completely new kind of mouth on a blank card. These action cards can provide some structure, for example in a brainstorming session, and help keep the tool interactive. Next to that, they could help when the creative process gets stuck at a certain stage.

5.3.2 Content Framework cards

As initially described in Section 5.2.1, these cards would represent the main categories of the database. These categories are: *cartoonish, human-like, function defines form, helmets and anthropomorphic human*. As discussed in Section 2.2.2 on categorization methods, these categories are different from what is found in the literature. Literature makes use of *anthropomorphic, zoomorphic and function defines form*. The goal of the Framework cards is to provide a sort of silhouette of a robot per category. However going over all the available options for robots, the realisation came that this is nearly impossible. Just the category of *function defines form* alone already has so many types of shapes that it is impossible to draw this on only one card. Therefore the option to change the content of Framework cards to just contain the facial shapes were made. Facial shapes are for example round and square, but also animal-like and helmet-shaped. It also creates more freedom for the user to not only have to stick to one main category, which allows for more creativity. And therefore no change in categorization labels is needed in the database.

5.3.3 Content Feature cards

As for the content of categories of the Feature cards, more detail-specific attributes used in the database can be used. The goal of these Feature cards is that when combined, a full face can be designed. Therefore it should have all the main components of a robot's face. In Section 2.3.1 all the elements of robot faces have been described.

(1) Eyes
    (a) Eyelashes
    (b) Eyelids
(2) Eyebrows
(3) Nose
(4) Mouth
(5) Ears
(6) Face shape

These categories are a combination of DiSalvo et al. [11], and their findings on the presence and influence of features on robot heads, together with the research of Phillips et al. [22]. However, there may be some other smaller, attributes to the perception of a robot's face, such as the presence of teeth or facial hair. Nonetheless, these smaller attributes are not included since it is difficult to determine how these smaller attributes contribute to the perception of the robot's face.

5.3.4 Symbol coding

Since the direct link to the main categories was removed from the Framework cards, a new option to create this connection was explored. This is important because it helps to better understand your design when you know where certain elements originated from. Nonetheless, it is important to allow and even encourage designers to walk between the lines

of categories to create space for creativity. Therefore this connection should not be the focal point of the design.

The concept of adding small symbols that relate to the main categories was added. These symbols would represent where that feature is most often used/seen in. And while the current categorization is not actively used in literature, it does create a good set of different robot faces. Next to that, due to time constraints, re-categorizing all robots was not seen as of high importance. Therefore the symbols will make use of the current categorization method: *cartoonish, human-like, function defines form, helmets and anthropomorphic human*. So for example, the Feature card of human realistic eyes will contain the symbols of anthropomorphic and human-like.

5.3.5 Design board

Since the concept contains a lot of different stacks of cards, some structure would help to enhance the usability of the tool. Inspiration was taken from The Tiles for the Internet of Things, in which so-called cardboard was made [43]. This design board supported how the cards can be logically placed, together with promoting the use of for example storyboards and elevator pitches. For this concept, a simple layout was made to help the user better understand the concept of the tool.

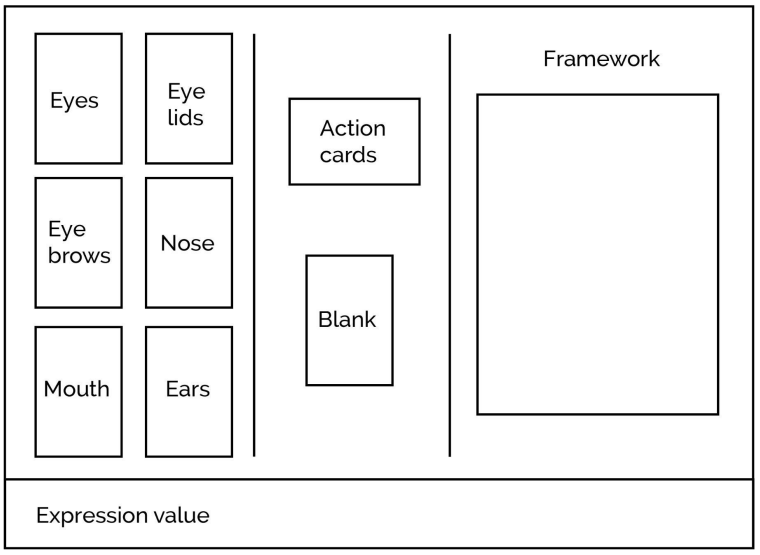


Figure 24: Layout design board

5.3.6 NFC chips

The tool serves as an extension of the database. Therefore a direct connection to the database helps encourage users to use the website. One way to make this connection can be formed is by placing NFC chips on the cards that redirect you to the site of the database. This way you transform the entire card to being an NFC. NFC chips are small flat chips that can easily be linked to anything and can be read by most smart devices.

The first option would be to place these NFC chips on the examples and let them redirect to the page of that example. Another option would be to redirect the chips to the

page of the robots which contain that feature. Since the chips would take up some space, also on the smaller Feature cards, placing multiple chips on the examples can make the card feel too loaded. Therefore, for now, the decision was made to redirect the chips to the page of all the robots which contain that feature.

5.4 Iteration Expression slider

After receiving feedback from the client, one major iteration was needed on the expression value. As explained previously, having an expression value would imply having a value on every Feature card that says something about the level of expressiveness of that feature. A high value would mean a high level of expressiveness, and a low level would mean a low level of expressiveness. However, when returning to the literature, the appearance of certain features does not only influence the perception of the robot, it is also important to how that feature moves and interacts with the user. This also counts for expression. Human-realistic eyes that do not move or interact with the user, are way less expressive than simple cartoonish eyes that follow the user and for example also blink. Therefore giving a strict value to each feature would be very complex to do correctly.

In order to eliminate this problem, but still partly include it in the concept, the change of putting expressiveness on a scale has been made. It is still correct that some features are more suitable for some level of expressiveness. Take again the example of human-realistic eyes, they are very suitable for a high level of expression, and it is often also expected. Giving the user an indication, where possible, of what part of the scale of expression would be (low or high), would help users make more informed decisions. And it will give users a better comprehension of what expression entails. This will hopefully make the user feel less restricted to using features outside of their 'normal' level of expression, while still giving them something to rely back upon. The importance of whether the feature interacts and moves will be stressed to the user through the design board.

As discussed in Section 2.3.2 several dimensions influence the perception of the robot when moving. These four dimensions have been used to make four scales of expressions for the features.

1. Eye operation
1. Mouth & jaw operation
2. Eyebrow operation
3. Head operation

This results in the fact that not every card will indicate the level of expression. For example, the category of noses will not describe something about the expression. This decision was made since that feature is way less influential and also usually does not interact with the user. The same was done to the feature ears. Next to that, some cards are thought to be good for every level of expression. When this is the case the indication of 'All' will be placed on the card.

Sliders will be added to the design board that represents these scales. Users can then set each scale at a certain level and constantly refer back to this level, and change when needed. This

allows for a constant check by the user whether the chosen features match that level of expression. And this goes both directions. The user can also change the slider to a certain level when they like a feature that much, but it doesn't suit the set level of expression.

5.4 Final concept

The brainstorming sessions helped form multiple sets of concepts that help give an idea of what the tool could look like. Especially the functionality brainstorming session helped to generate a good possible concept. Due to time constraints, a difference in priority levels is made between all the elements. Doing so helps to determine which parts require more focus.

Concept elements	**Priority**
Framework cards (based on facial shape types)	High
Feature cards	High
Expression value	High
Design board	High
Symbol coding	Low
NFC chips	Low
Action cards	Excluded

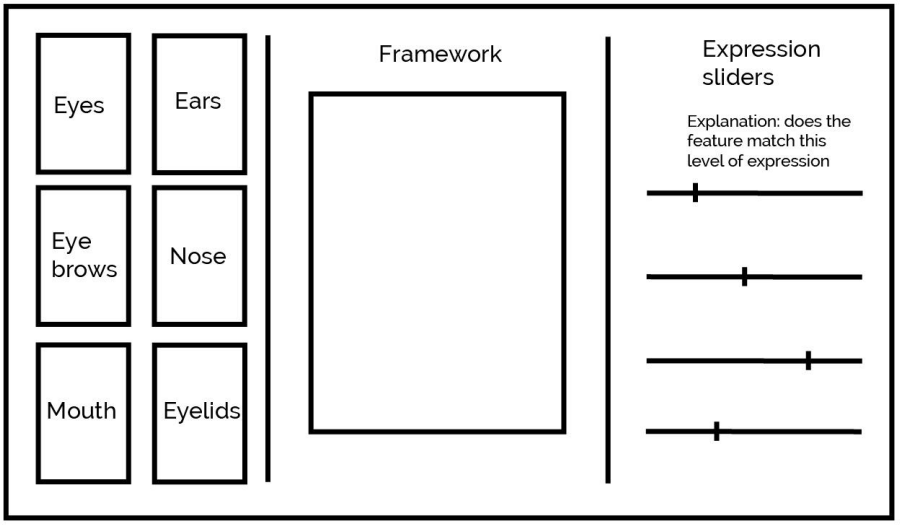
Table 3: Elements final concept with their priority level

As seen, the concept of action cards is excluded. This decision has been made after taking a critical look at the consequences of these cards. The risk of having these cards is that users immediately draw one of those cards, and are not pushed to think of something themselves. It would form too much of a focal point when included, and therefore the design has been made to exclude it from the concept.

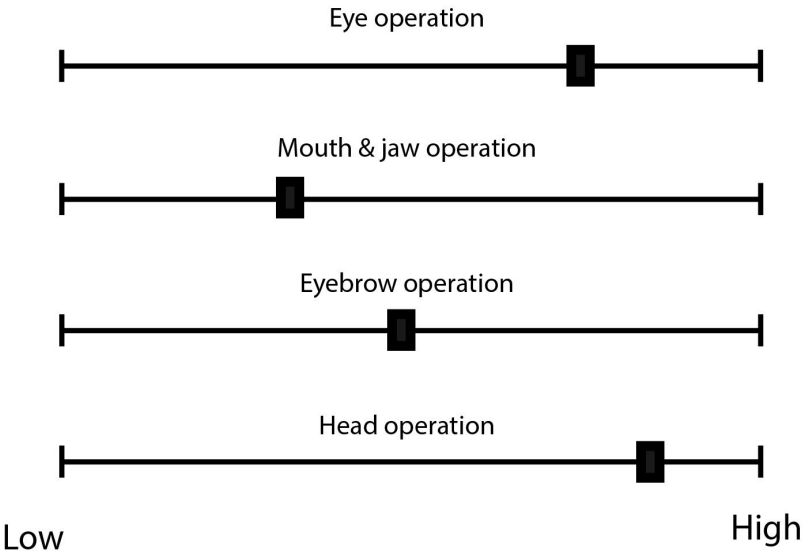
Multiple parts of the content of these cards have been thought out of. For example, the types included categories on the card. However it is important to note that this is still a concept, and therefore iterations will be made. Next to that, there are still some parts that need to be thought out within the following phases. However, when relating this concept to the preliminary requirements, overall positive satisfaction is created.

The following figures show a visualisation of the previously explained elements. Since the iteration of the expression, sliders were made, and a re-design of the design board was needed to suit the concept.

Design board



Expression slider



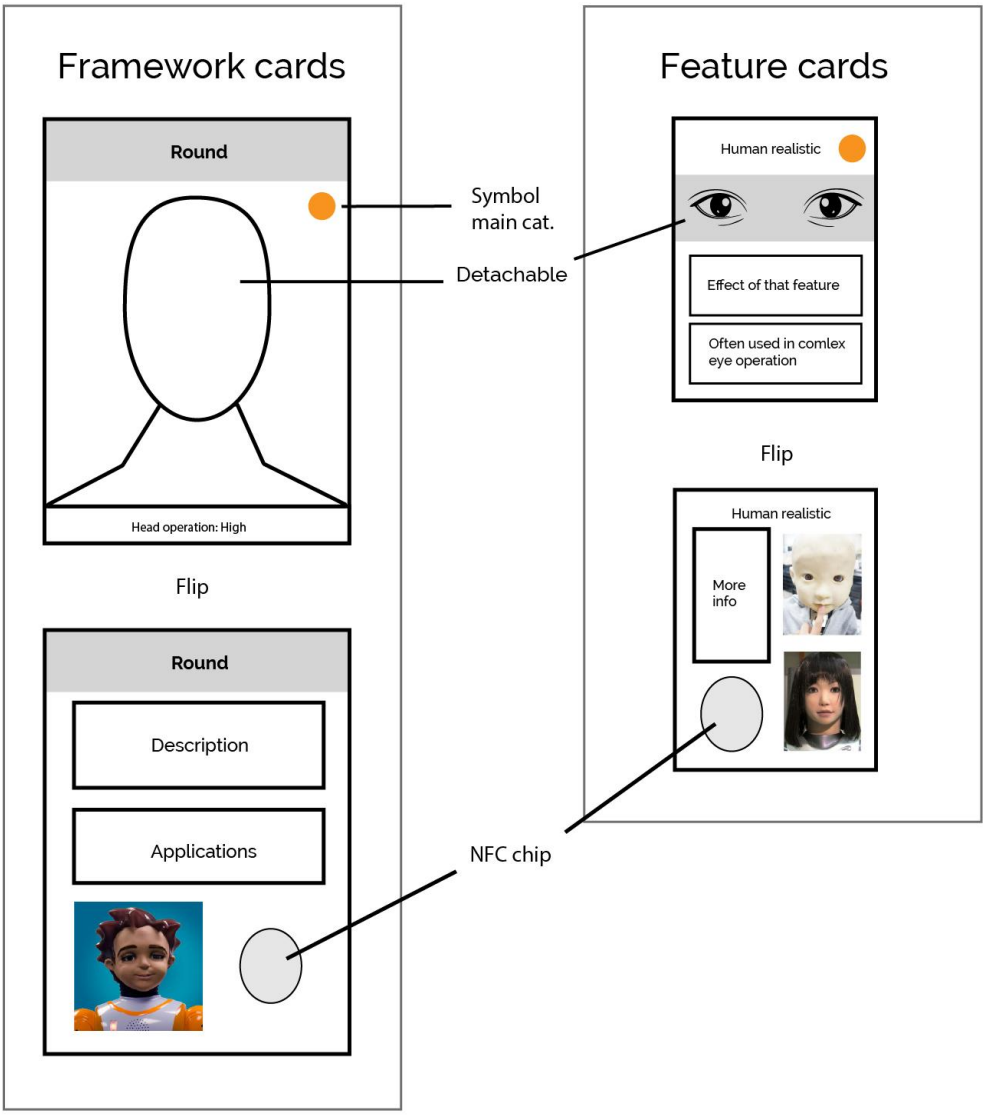


Figure 25: Visual representation final concept

Chapter 6 - Specification

Within the specification phase, final requirements will be made to help develop an effective product. These requirements are created from the knowledge gained by the previous chapters, and will both be a revision as an extension of the preliminary requirements made in Section 3.3. Before setting up the list of requirements, three personas of possible end users were created. These personas were inspired by Section 3.1.1. The personas are then used in multiple interaction scenarios to help understand how the product will function. This information is used in setting up the final requirements. The requirements will be divided into two categories: functional and non-functional requirements. Functional requirements define what the product should do, so describe certain behaviour. Non-functional requirements specify how the product should behave, so describe certain qualities. Functional requirements can be assessed objectively, while non-functional requirements will require subjective evaluation.

6.1 Personas

Personas are a description of fictional characters that are end users of the final product. They help understand the user in terms of their needs and interactions with the end product. As described in Section 3.1.1, the design tool has two main end users; users who have prior knowledge of facial robot design, and users who don't. Both of these groups may interact differently with the product and are therefore interesting to describe separately. For example, users may use the tool differently for commercial purposes and personal use.

Next to these two groups, another persona was developed of a user who is already experienced with the design tool. This will give interesting insights into important prospects of the tool for experienced users.

The personas were created with an Xtensio User Perona template [52]. All the images used within the personas are not real persons [53].

6.1.1 Persona 1: No prior experience and not familiar with the tool

Sandra Barend

Outgoing | Social | Focused | Perfectionist

Age: **27**
Work: **Graphic Designer**
Family: **Single**
Location: **Groningen**

Goals

- Creating visually pleasing products
- Doing work outside her normal field
- Matching the user's needs to her designs

Frustrations

- Reading long academic papers
- Having unclear and inefficient communication within the team
- Clients that do not understand what they want

Personality

Introvert	Extrovert
Thinking	Feeling
Sensing	Intuition
Judging	Perceiving

Bio

Sandra has been working for some time at a young, large company in Groningen. After she finished her studies in graphic design, she first got an internship and then a job at this company. She has been primarily working in 2D graphic design; however, she has indicated that she is up for a new challenge. She has always had an interest in robots, so when her manager introduced her to this new project in which the appearance of a new healthcare robot will be developed, she was really enthusiastic. She got assigned to the team of the face of the robot. During her research, she finds a lot of different information about facial robot design, which makes it hard to see what is relevant to her project. She finds it hard to ask for help since she gets the feeling the others in her team are way more experienced than her.

Figure 26: Persona of Sandra Barend

6.1.2 Persona 2: With prior experience and not familiar with the tool

Vincent Castro

Friendly | Ambitious | Resourceful | Businesslike

Age: **34**
Work: **Manager hardware team**
Family: **Married**
Location: **Rotterdam**

Goals

- Make sustainable products
- Spend more time with his family
- Bring over some of his tech knowledge to his kid

Frustrations

- Over-complicated business structures and workflows
- Finding inspiration for new projects
- Sketching digitally

Personality

Introvert	Extrovert
Thinking	Feeling
Sensing	Intuition
Judging	Perceiving

Bio

Vincent works for a large tech company that builds chips. For the last couple of years, the job was rather time-intensive. So recently he has decided to focus more on himself and his family. He decided to pick up something from an old job as a hobby, building robots. At his last job he was the manager of the robot team, so he has a lot of overall knowledge in this field. A friend of his recommended the robot facebook to get some inspiration, and on the website, Vincent stumbled upon the design tool. He decided to give it a try for his toy robot.

Figure 27: Persona of Vincent Castro

6.1.3 Persona 3: With prior experience and is familiar with the tool

Alina Marza

Sympathetic | Self-critical | Assertive | Patient

Goals

- Being a good team member while still working independently
- Using her expertise in human-robot interaction within her work
- Expanding her software knowledge

Age: **27**
Work: **Robots engineer and designer**
Family: **In a relationship**
Location: **Enschede**

Frustrations

- People that are not open to new ideas
- Team members not meeting deadlines
- Companies not wanting to invest in their employees

Personality

Introvert	Extrovert
Thinking	Feeling
Sensing	Intuition
Judging	Perceiving

Bio

Alina has been working hard in her team at a robotics company. She has accompanied multiple projects and has tried to use her expertise in human-robot interaction in order to build better and more efficient robots. Recently she got involved in a project for a new robot that will be used in large movie production. For her last projects, she used the Robot Facebook design tool and was very enthusiastic about how it worked within the team. This time she wants to use the tool to communicate with her clients about their needs. She brings the tool to one of their meetings in order to brainstorm together on the project.

Figure 28: Persona of Alina Marza

6.2 Interaction scenarios

Scenarios describe a situation in which a persona is used within a certain context. This shows how each persona might interact with the product, which helps to better understand the interests and needs of the user. For each persona, a different scenario in which the design tool is used is described.

6.2.1 Scenario 1: Sandra

Sandra has been challenged at her job to work on something outside of her normal domain of graphic design. So has been challenged to make the design for the face of a new healthcare robot. She has no prior experience in designing robots and faces. During her research before making the design, she found a lot of complex academic information, which did not make a lot of sense to her. Later in her research, she stumbled upon The Robot Facebook design tool. Due to her lack of experience in the field and the promise not being hard to ease, she decided to give it a try.

1. Typing in The Robot Facebook on Google and clicking on the tab 'Design tool' brings Sandra to the page of the tool.
2. She reads through the explanation of the tool, and after discussing it with her manager she decides to order the full package instead of assembling it on her own.
3. After the package has arrived at the office, she opens it up to see the cards, the design board and some instructions.
4. She continues flipping through the cards and scanning the information on them. She already read the instructions on the website so she kind of has an idea of how to use the tool.
5. After showing it to one of her colleagues, Sandra decides to have a brainstorming session by using the tool.
6. First, she wrote all the requirements down she got from the client and members of the other team. This helps her to get an overview of what is important for the design.
7. Then Sandra tries to pick a framework for her design, however, she comes to the realisation that she has not paid much attention to the expressiveness of the robot.
8. She decides to bring her manager to this project to discuss this with her. Together they settle on the fact that the healthcare robot should be somewhat expressive to build up sympathy with the user, but not very complex to lower costs in building (so mid/high).
9. Having this new knowledge, Sandra can continue her brainstorming and pick a good framework for her design.
10. She continues by going over the other categories and picking features that also match the level of expressiveness she and her manager talked about.
11. Eventually, she was happy with the features and settled upon them and decided to draw some last details on the framework with the whiteboard markers that were included in the package.
12. During a meeting with members of other teams, she shows her design and talks them through why she decided on certain features. She gets some questions and feedback from her colleagues.

13. Sandra returns to her design, implementing the feedback she got from her colleagues, and making some changes.
14. After adapting her design, she sends it to the client for approval, hoping they like what she made.

6.2.2 Scenario 2: Vincent

Vincent wants to pick up an old interest of his, building robots. He has quite some experience with this since he has done it professionally. For now, he wants to start a new project as a hobby, and maybe bring over some knowledge to his kid along the way. To get some inspiration for the project he scrolls through the internet, and by accident finds The Robot Facebook design tool.

1. Vincent scrolls through the Robot Facebook website and reads the page of the design tool. Since this project is a hobby he decides to download the free files of the tool, instead of buying the package, and later assembling it himself.
2. He flips through the cards and is reminded of his old job. He recognizes a lot of the information and features.
3. After giving it some time, and discussing it with his husband and kid, they settle on the functionality of the robot, and somewhat on what it will look like. A small toy robot that follows you and that makes fun noises.
4. Vincent decides to give the design tool a shot, also since he hates making sketches digitally and therefore hopes the tool will help him out.
5. He understands the overall importance of expression in robots, however, decides for this project it will not be the main focal point. The focus point should be having fun, and making a cute robot. Therefore he does not base his decisions on this factor.
6. He is intrigued by the many options of features and lays out several combinations on the table. He shows them to his kid, and together they make a selection of the best design.
7. Vincent decides that the design given by the tool has given him enough support to build the robot, and therefore finds it unnecessary to make a digital sketch.
8. The project continues with the actual building of the robot but is constantly referred back to the design made with the tool.

6.2.3 Scenario 3: Alina

Alina is both familiar with facial robot design and the design tool. She has used the tool multiple times in projects for the company she works for. Right now she is faced with the challenge of designing a robot for a large movie production. Since she was so enthusiastic about the tool, she decided to use it in a way she has never done before.

1. Alina has set up a meeting with the client of the movie production. In this meeting, she wants to make it clear what the requirements of the robot are.
2. Alina noticed that clients often say they want something while meaning something else. This frustrates her since it requires many more rounds of feedback compared to when gets it clear from the beginning.

3. She decided to bring the design tool with her, with the hope it would help her and the client get a better understanding of what they both want and what is possible.
4. During the meeting, Alina asks her client about the requirements of the movie robot, and after some time she brings out the tool.
5. Together with the client, Alina goes over several options for the design of the robot and gets immediate feedback when something does not match the client's vision. This helps Alina a lot to understand what the client wants.
6. With the expertise of Alina and the vision of the client, they can lay out several combinations for designs.
7. After the meeting has been finished, Alina immediately has some ideas for an actual design.
8. She decides to leave the tool for what it is and starts making a final digital sketch.
9. After sending it over to the client for approval, she noticed that it required way less feedback to get a final design.

6.3 Requirement list

A list of requirements helps to see whether the product satisfies the user's wants and needs. As previously mentioned, these requirements are a revision and extension of Section 3.3. The MoSCoW method has been used to categorise the requirements to get an overview of which requirements are of higher priority [54]. The method uses the labels: must have, should have, could have and will not have.

6.3.1 Functional requirements

Nr.	**Functional requirement**	**MoSCoW**
1	The tool must be accessible through the current Robot Facebook website	Must have
2	The cards must show the State of the Art that is included in the database	Must have
3	A description of the showed feature must be included on the cards	Must have
4	Every category of features should include at least 4 cards	Should have
5	The database should be updated with at least 5 new relevant robots	Should have
6	Symbols should be added to the cards that show in which main category of the database that features is often seen in	Should have
7	The expression sliders are physically movable	Could have
8	Users are able to draw on the cards	Could have

9	There is a direct technological connection between the tool and the database	Could have

Table 4: Functional requirements

6.3.2 Non-functional requirements

Nr.	**Non-functional requirement**	**MoSCoW**
1	The tool should help provide structure in the process of designing a robot's face	Must have
2	Allow for easy iterations of a design	Must have
3	Should allow flexibility in usability	Must have
4	Should help users make informed design decisions	Must have
5	Should be intuitive to use	Should have
6	Should be usable by multiple people at once	Should have
7	Should be easily portable	Should have
8	There should be a logical connection to the database	Should have

Table 5: Non-functional requirements

Chapter 7 - Realisation

The realisation phase is used to create a prototype. The actual product is made along the previously made requirements. The final concept from Section 5.4 is taken as the starting point of the design, however, some iterations were needed to finalise the product. For example, necessary changes after receiving feedback from the client. Within the following chapter, every part of the product is discussed and shown.

7.1 Database update

As part of the requirements from the client, the database needed updating. The last addition was done in 2017, and the domain of robots has continued to grow intensively. So five new robots were included. The same strategy of selecting robots for the database described by Eva Velt was used to minimise the risk of selecting irrelevant robots. This selection is based on whether the robot is seen as impactful. Next to that, the same list of attributes was used. This allows for easy comparison between robots. The new robots are mentioned in Table 6.

Name robot	**Category**
Ameca [49]	Anthropomorphic human
Lovot [55]	Cartoonish
Plato [56]	Cartoonish
Aibo [57]	Cartoonish
GUS (Ground Unmanned System) [58]	Function defines form

Table 6: Five new added robots in database

Updating the database is also relevant for the design tool. The cards show examples of robots which are currently included in the database. Including more up-to-date examples provides users with a better overview of the current State of the Art, without them even looking at the entire database. A preference for example was given to a newer addition when this decision had to be made.

7.2 Framework & Feature cards

The basis of the design tool is the Framework & Feature cards. The two card types are rather similar products, with the main difference of the Framework cards being a lot bigger than the Feature cards. The idea for these cards is that users can detach the illustration part of the feature, and attach it to the framework. This way users can build a new robot face.

One of the iterations made after receiving feedback from the client was leaving out the category of eyelids and eyelashes from the Feature cards. This was necessary due to more practical reasons. Eyelids and eyelashes are already included in the illustrations of eye

features and are therefore almost impossible to separate. Therefore the decision was made to combine the category of eyelids and eyelashes with the category of eyes.

There are a lot of features that can be included within the tool. However, due to the time constraints of this project, it is nearly impossible to include every feature. A selection of features was made based on the robots that are in the database. For each category, there is a list of attributes shown in the 'Advanced Search' option. From these attributes, the features were picked if they represented a distinct, drawable category. Sometimes listed attributes were combined, or a new one was added. After picking the attributes, an observation was done through the database to analyse whether these attributes cover all the features. Table 7 describes which attributes were used for which feature.

Feature	**Attribute in database**	**Number of developed cards**
Framework	Facial shape	6
Eyes	Eyes, Eye Specification	6
Eyebrows	Eyebrows	4
Mouth	Mouth	6
Ears	Ears	5
Nose	Nose	4

Table 7: Overview developed cards

For each feature, a description was written and two clear examples from the database were picked. Next to that, an illustration was chosen/made. Some of the used illustrations are open-sourced drawings, and others were self-made. A table with a full overview of all the information can be found in Appendix A.

7.2.1 Symbols

In order to include the main categorization of the database, symbols were added on the cards that represent in which category that element can be most often seen. In several cards, this results in multiple symbols. These symbols were made in Adobe Illustrator. An additional card, the same size as a Framework card, was added that explains these symbols.

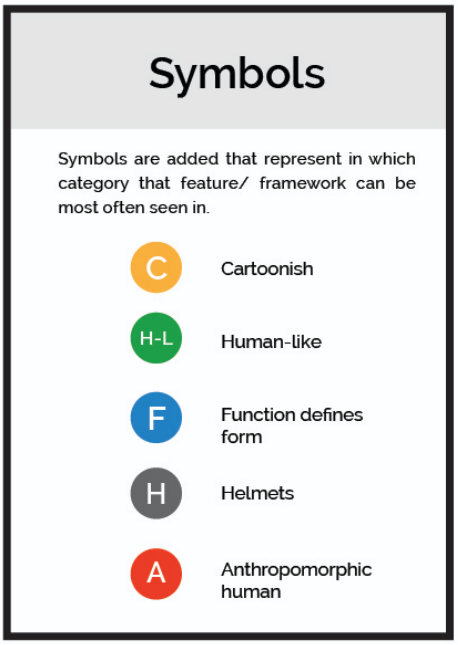


Figure 29: Design of Symbols explanation card

7.2.2 Gradients border

The border of each card has been given a colour gradient that represents the level of expression. The category of Nose and Ears are not significant in the perception of a robot face and are therefore not given a gradient colour. However, to easily separate all the categories, these two categories also have been given distinct colours. An extra card the same size as a Framework card has been included that shows and explains these colour gradients.

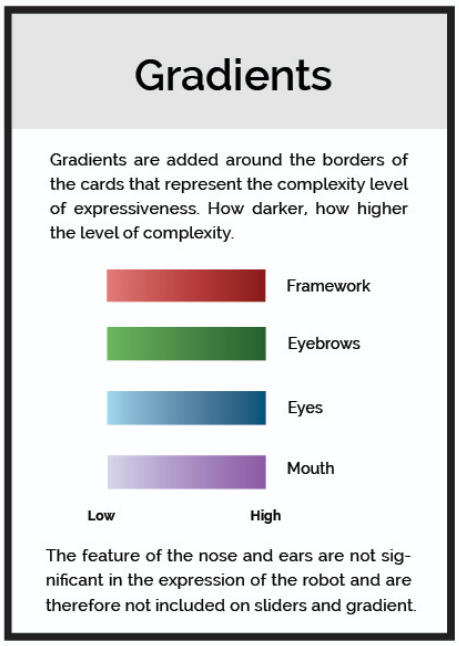


Figure 30: Design of Gradients explanation card

7.2.3 Design Framework & Feature cards

The design of the Framework & Feature cards was made in Adobe Illustrator. The examples used needed more space than first imagined, therefore the design was changed to only having text on the front, and two examples on the back. The illustration of the Feature cards was created separately to allow for it to be detachable. An example of one feature and one framework design can be found in Figure 31. For a full overview of all the designed cards can be seen when downloaded on the website [59], and in Appendix A.

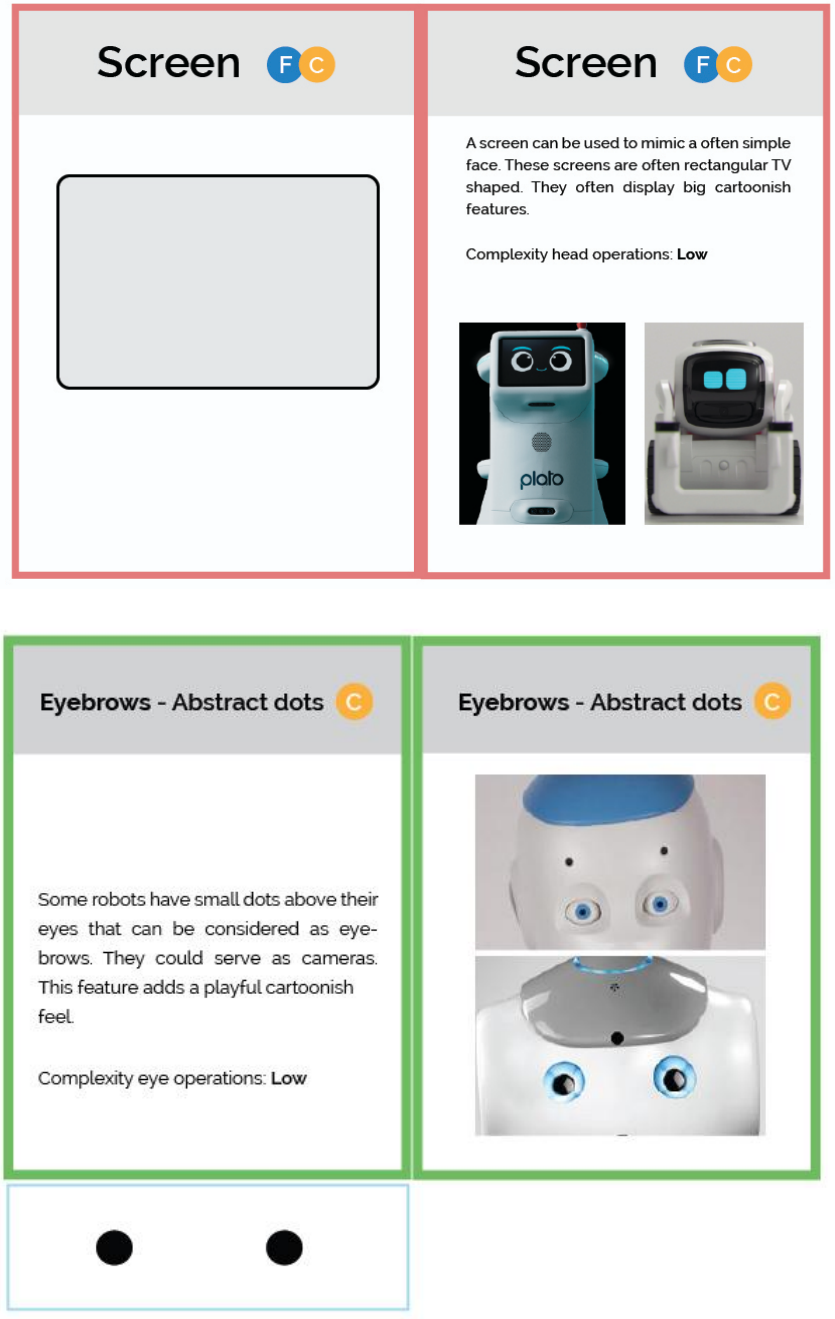


Figure 31: Design of Screen Framework & Abstract dots Eyebrows card

7.2.4 Prototype

The designs of the cards were converted from a vector file to a PDF for accessibility. Each card has been sized to fit on A4, however, the Feature cards are significantly smaller. Magnetic tape has been used to make it possible for the illustrations to stick to the cards [60]. This tape was attached to the illustration and on the inside of the cards. And it allowed for easy movement. The Framework cards have been laminated to give a more sturdy feel and also create the possibility to draw on them.

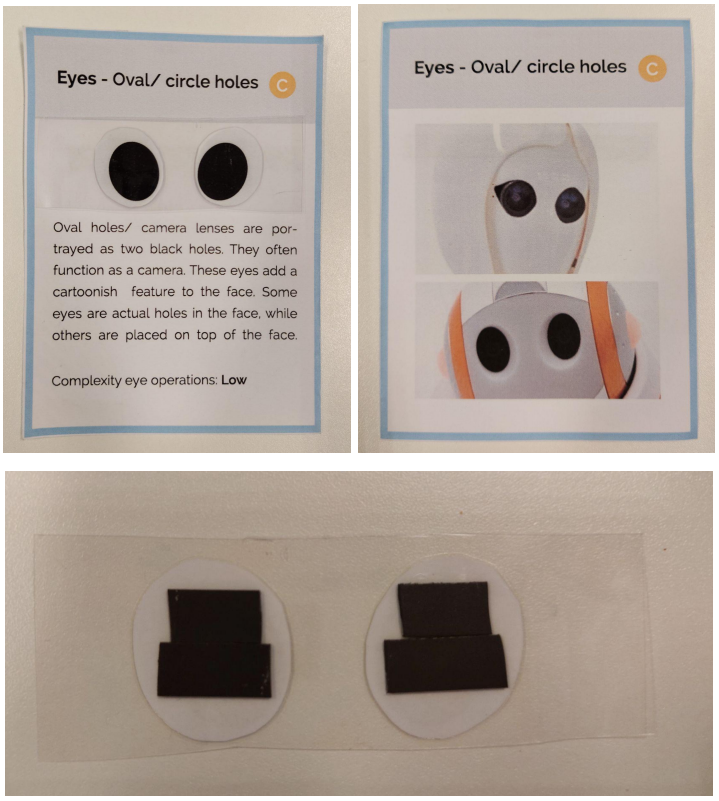


Figure 32: Oval/ circle hols Eyes Feature card

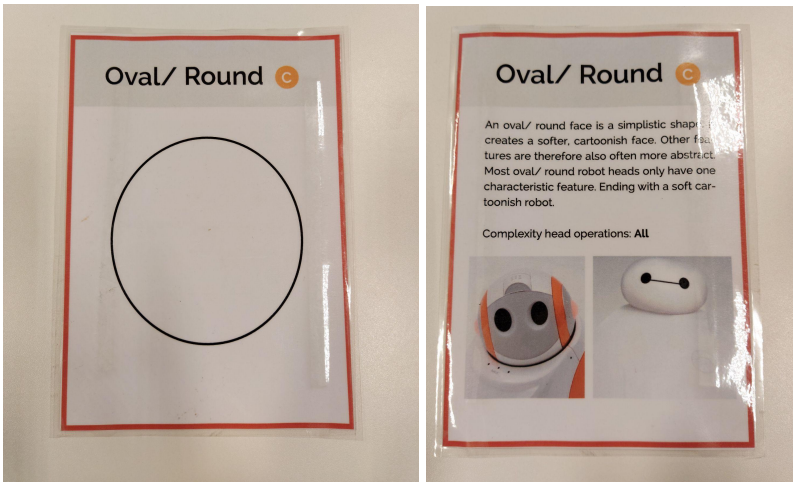


Figure 33: Oval/ round Framework card

7.3 Design board

The goal of the design board is to provide structure and show information about the tool. The design board needed some alterations after having all the information that needed to be displayed on it. This information needed more space was needed than planned. It eventually resulted in the design seen in Figure 34.

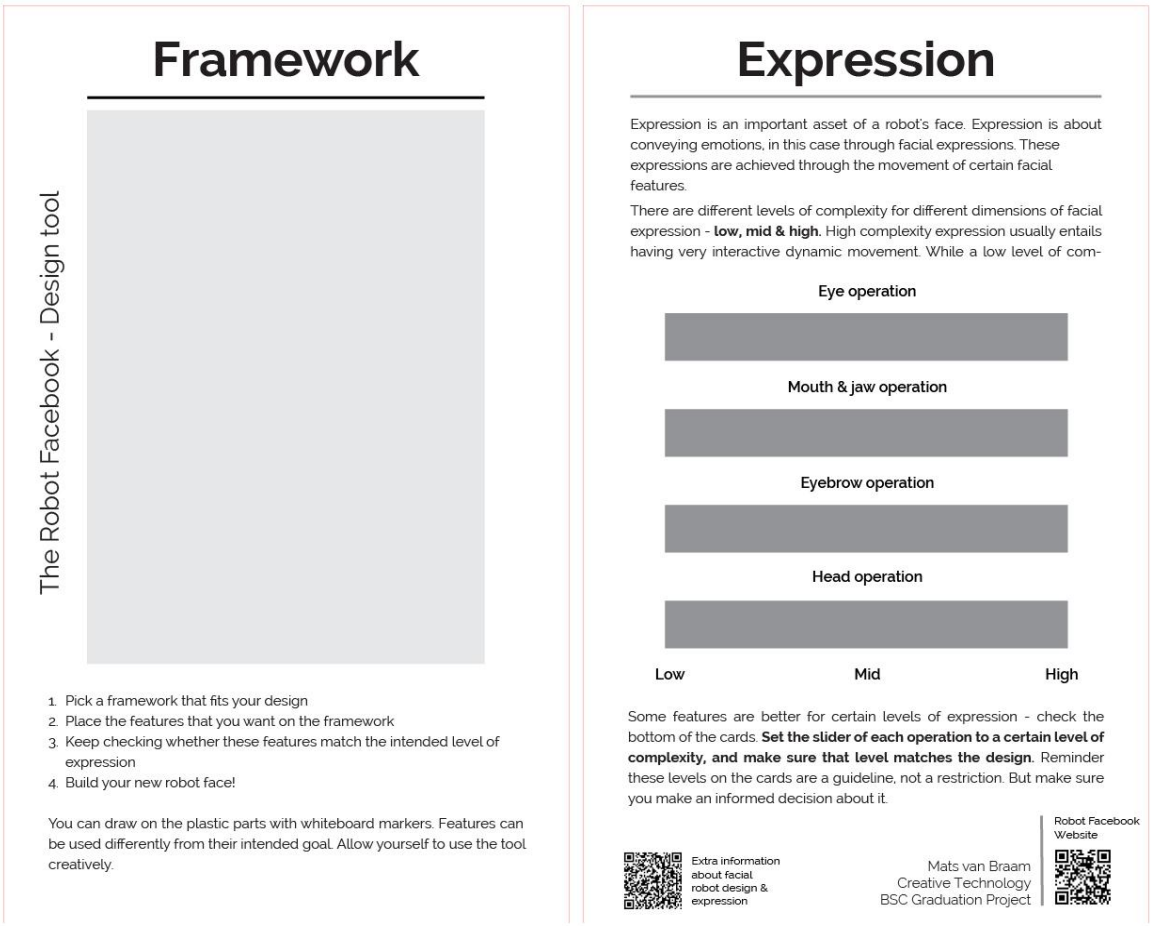


Figure 34: Design board

A laser cutted wooden plate was used for the board. A laser cutter allows for a nice display of text, and compared to paper, it provided a more sturdy feel. A thin magnetic plate was added on the framework side in order to allow for the illustrations to stick to them.

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7.3.1 Expression sliders

For the expression sliders it is important and a requirement that it could physically move. Several materials and options were considered, and eventually, small parts of curtain rails were used as sliders. The slider itself has the nice option of tightening it within the rail to lock it.

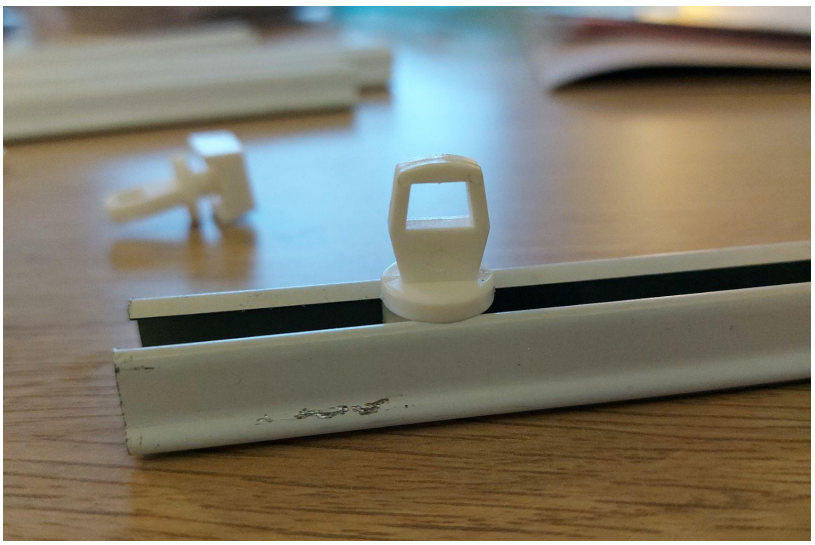


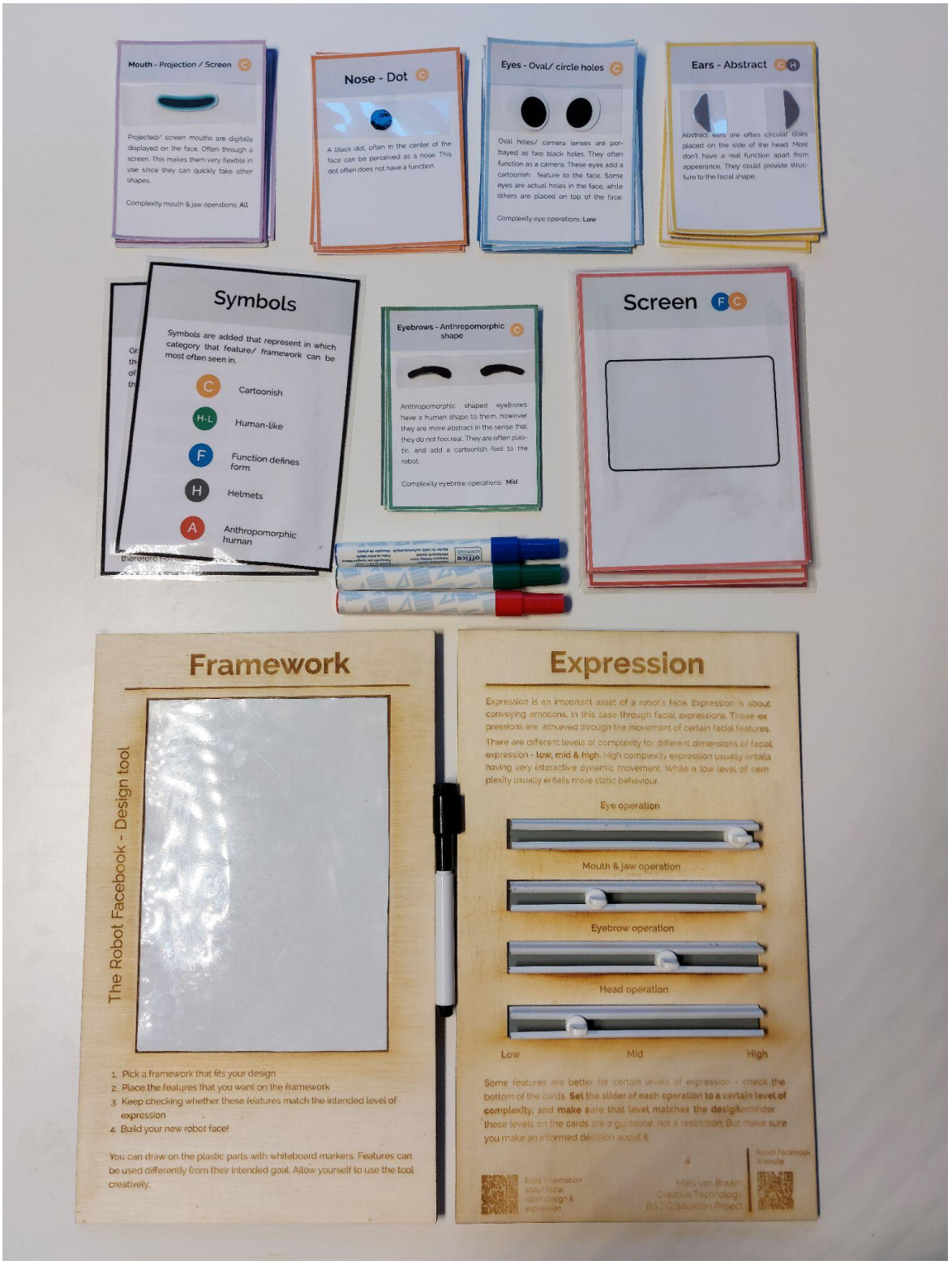
Figure 35: Material Expression sliders

7.3.2 Prototype

Figure 36: Prototype of complete Design board

7.4 Hi-Fi Prototype Design ToolT

When combing all of the previously mentioned concepts, results in the Hi-Fi prototype as seen in Figure 37. Whiteboard pens were included to allow users to draw on the Framework cards. More pictures of the prototype can be found in Appendix I.



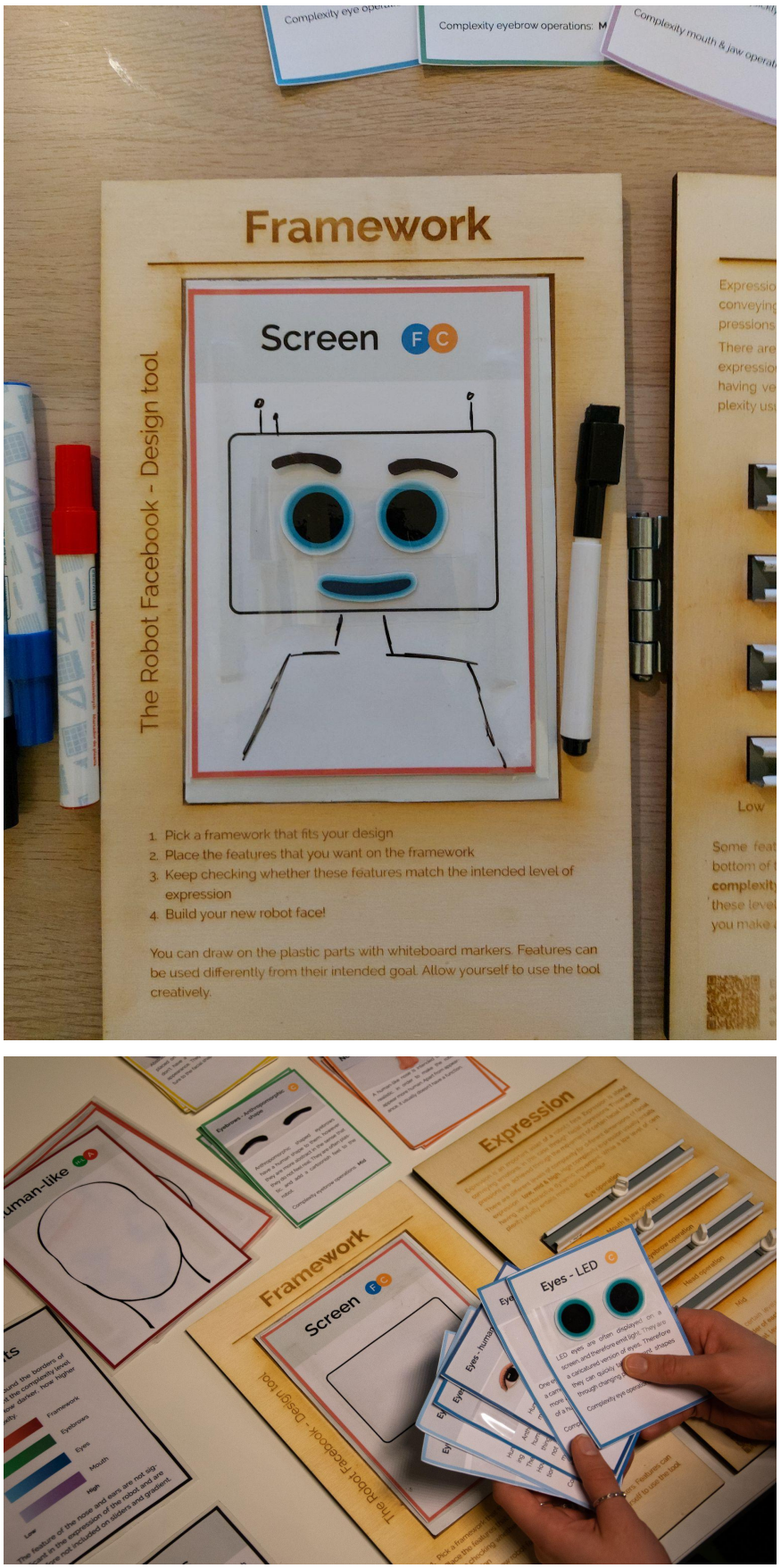


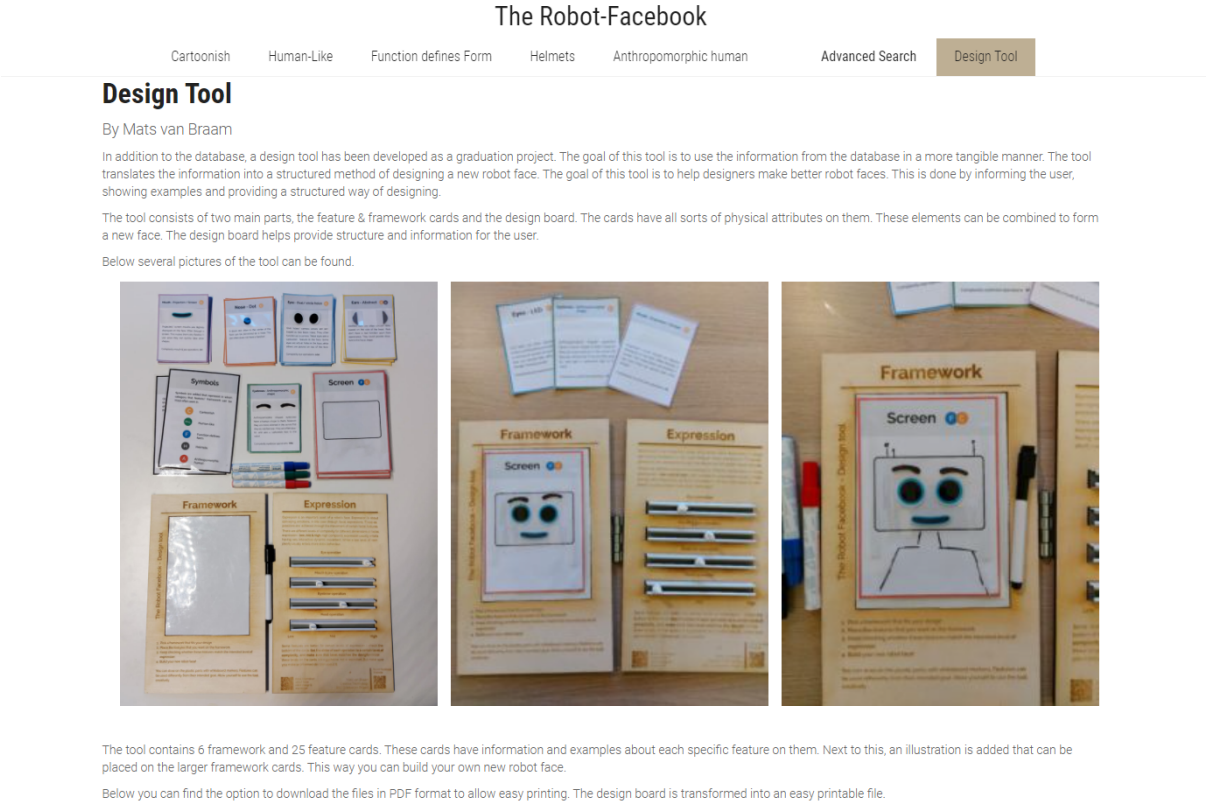
Figure 37: Pictures of final Hi-Fi prototype

7.5 Implementation website

The database is displayed on a WordPress-managed website. WordPress allows for easy management, such as making additions. Next to the several newly added robots, a new heading for the design tool was created. This heading is placed next to the 'Advanced Search' button at the top. Clicking on this button brings the user to a new page where the Design Tool is explained. Next to an explanation, several photos of the tool were included to give the user a good impression.

Apart from the explanation and photos, downloadable files of the cards and the design board are included. Both files are in PDF format to allow for easy printing. The design of the design board has been somewhat adapted to fit easy printing.

Finally, two linked pages are included for viewers that want more information. One link redirects the user to this report, and the other link redirects the user to a short report on facial robot design of which the QR code is also included on the design board.



Download here

Design board Download

Cards Download

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Extra information

If you want more information about facial robot design check this file:

Research Facial Robot Design

And if you want more information about the project, check this report or please contact Mats van Braam (matsvanbraam@gmail.com)

XX

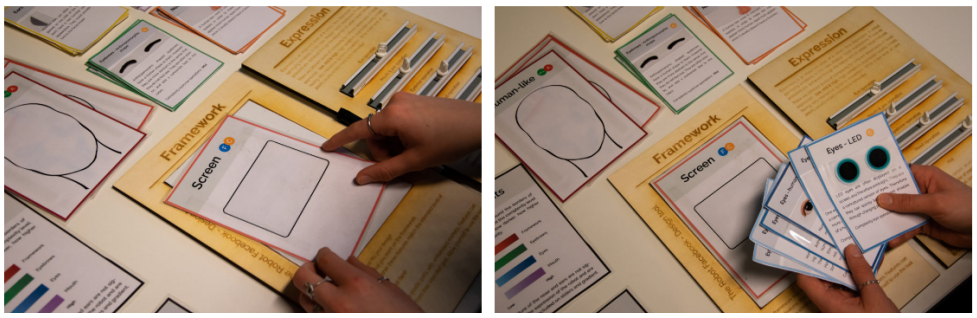

Figure 38: Implementation of the Design tool on the website

8. Evaluation

In order to see whether the developed product matches the way it was intended, an evaluation in the form of a user test is performed. Next to that, the goal of the user evaluation is to get an insight into the requirements described in Section 6.2. The participants of the evaluation are possible end-users of the product, and therefore important stakeholders. Within the first section, the plan of evaluation is discussed. This will describe the procedure of how the evaluation has taken place, together with its intentions. Next, the results are systematically discussed. Eventually, a conclusion and discussion about these results are given.

8.1 Evaluation plan

Evaluating the Robot Facebook design tool has two goals. First testing the usability and second understanding the user experience of using the tool. This way conclusions can be drawn for example about the workflow of the tool and the users' initial reaction. The user evaluation consists of two groups of participants, A and B. Group A is asked to perform a more explorative user evaluation. This is done by asking them to create a completely new robot face based on a scenario. Group B performs a more comparative test. They are asked to redesign a robot based on a similar scenario. The structure of the user test was similar for both groups - only the intentions of the tests are slightly different.

The intention of testing with Group A is to see how users naturally interact with the product. So seeing and asking which steps they take to come up with a new design. The test with Group B is more aimed at evaluating whether participants make use of the actual information of the tool.

The first part of the user test consists of interacting with the tool through means of an imaginary case scenario. After participants have finished their design, the user evaluation shifts to an interview. The participants are observed during the first part. From this observation, conclusions about the tool's usability can be drawn. The interview mainly focuses on the user experience. By evaluating both elements, a better understanding of the effectiveness of the tool is gained.

Before doing an actual user test, a pilot was performed. This pilot was done in the same manner as a real user test, and eventually helped improve the structure of the test. The real user tests took around thirty to forty minutes. The interviews were recorded with permission from the participants to later transcribe. The recordings were deleted after completing the transcriptions.

8.1.1 Participants

In total seven participants were asked to take part in the user evaluation. These seven participants were used in six user evaluations. One of the user evaluations was held in pairs. Two different types of participants took part. Three of these participants had some experience in robot design (for example took the course Social Robot Design), and four participants were inexperienced with robot design. This distinction helps understand whether there are differences in use between two groups of stakeholders. The hybrid user

evaluation will give an interesting insight into the dynamic between users when using the tool. It is interesting to see how they use the tool to explain their choices to each other. Together this leads to the following number of user evaluations:

Group A (Explorative):

1. One experienced user
1. One inexperienced user
2. A pair of one experienced and one inexperienced user (hybrid)

Group B (Comparative):

1. Experienced user
2. Inexperienced user
3. Inexperienced user

8.1.2 Evaluation setup

All the evaluations were conducted in real-life. Participants received a consent form and information brochure at the start of the user test, see Appendix G and H, respectively. The consent form is needed to allow the use of the acquired data. The information brochure contains some information about the project and the procedure of the user test. Some additional information about the participant's rights is included. Then the project is further explained and the tool is shown.

An imaginary case scenario is handed to group A. These scenarios can be found in Appendix C. This case describes a new robot, and the participants are asked to design a robot face according to that scenario. The descriptions are intentionally somewhat vague to allow the most creative freedom of the participant. Every user evaluation in the groups will get a different case scenario to maximise the use of all the cards.

Group B is asked to redesign a robot based on several requirements. A design made by the researcher on the tool is handed to them. Next to this design, comments are provided on how that design should change. The same scenarios were used for Groups A and B, however, only for group B the additional feedback comments were shown.

The participants were then asked to use the information and material of the tool, to (re)design the robot how they see fit. Before the participant starts interacting with the tool, it is stressed that there are no wrong answers/designs, and there is also no wrong way of using the tool. The participant is asked to use the think-aloud method. Interesting observations and remarks will be noted by the researcher.

If the participant is satisfied with their design, the user evaluation shits to a semi-structured interview. The audio of this interview will get recorded to allow the researcher some freedom in the interview. When interesting topics come up, or more clarification is needed, new questions will directly get asked to the participants. The list of questions and transcriptions of all the interviews can be found in Appendix D.

8.2 Evaluation results

The six user tests provided interesting insights into the effectiveness and enjoyability of the tool. The answers given in the interview were transcribed and can be found, together with some observational remarks, in Appendix D. To evaluate these results, patterns within the answers were looked for. Next to these patterns, the overall workflow of each participant is evaluated and discussed. Within these answers, interesting and surprising use or experience is searched for. The topics of evaluation are differentiated into two sections, one on usability and the other on user experience.

8.2.1 Usability evaluation

The participants were able to make a fitted design to their related case scenario. All participants indicated that there were enough options available. When a participant wanted to include something that was not on the cards, they used the pens, resulting in even more options. The average interaction time was 12 minutes. The hybrid user test (#2) took almost double this time, namely 20.42 min. This was because they took way longer to decide on certain features since they also had to convince one another. However, eventually, this did lead to a more conscious well thought design.

When analysing the workflow of each participant interacting with the tool, it stands out that every participant used the tool somewhat in their way, but the general workflow was very similar. The explanation on how the tool could be used was kept minimal to see what the natural flow of the product is. All participants first focused on the framework side of the tool and from there picked a Framework card. Then most participants started picking features, and at last, the expression part is executed. Based on this expression side, certain features sometimes got switched.

However, the way participants filled the framework was different for most. Some started by sticking random illustrations to the board, while others carefully picked all the features to eventually stick them to the board at once. The order of picking features was for some a conscious decision; they started with the most influential feature (eyes). While other participants chose the order of features completely at random. Multiple participants indicated that the level of freedom was very enjoyable. User test #2: "*It is nice that it is so customizable*". Most designers have their own workflow, and the tool provides a good foundation for this, however, it leaves enough space for flexibility in usability.

Almost all users were in the beginning so focused on the framework side of the tool that less attention is paid to the expression side. This resulted in the fact that users afterwards try to match the needed level of complexity to their design. They tried to match this through the descriptions and examples. It may be better to switch that order around, to match the design to the picked level of complexity.

How the focus can be changed is hard within the current format. One way to trigger people about this complexity earlier is to make it stand out more on the cards. This way users are earlier intrigued to ask what it means on the cards and look for an explanation on the expression side.

One thing that a participant mentioned was the confusion in the use of certain terms. User test #4: "*... something that was confusing was the different use of expression and complexity. I think maybe you can just rename this, for example, like the expression level...*". And while some terms should not be used interchangeably, more clarification could help improve the tool in general.

As mentioned earlier, including the whiteboard pens created a lot of freedom for the users. And while some participants didn't make use of them at all, others drew multiple features. All participants indicated to enjoy the possibilities of these pens. One participant suggested adding a piece to the board that serves as an attachment for the pens. This way no confusion is raised about whether the pens are part of the tool or not.

There were some other small fixes noted that will help improve the usability of the tool. One of them was about the gradients. The colour difference between high and low could be more drastic to help users see the difference more clearly.

Another small fix relates to the design of the framework cards. Currently, the complexity level of the framework cards is on the back. This is not very practical and should be added to the front.

At last, some more information about the example robots can be helpful. For example, including their names would help tremendously when a user wants to look up a certain robot.

8.2.2 User experience evaluation

The overall user experience was promising. Users seemed and indicated to enjoy the process of building an informed robot face. Participants said that the tool could be used in several ways. For example User #4:"*... really at the beginning of a project, you just need to decide what technology you're kind of gonna use, then it is a good tool.*". And that is what more participants indicated. They found it a good starting point for designing a new robot face, without needing a lot of prior knowledge. It provides enough direction to narrow down the direction of your project. Currently, it does not contain the ability to create a well-finished design, more something like a first draft. And this is sufficient for providing a direction in technology.

There are several elements that participants seemed to enjoy. The first is the fact that a tool, and especially the board, was a physical product. And while the wood may not be the best choice for large-scale production, it was a good option for the prototype. The tangibility of the tool helped put the users in a creative space.

Participants switched several options of features quickly around on the board. It allowed the user to see whether that option suits the design they had in mind or not, without making a heavy dedication to it. The magnetic tape allowed for this easy switching, and just like the wooden board, it may not be the best option for large-scale production, but for the prototype it was well-received.

The hybrid user test was one of the most successful in the sense that they made very conscious informed design decisions. Other participants also indicated that the tool would be

good to use in a group dynamic. And while only one user evaluation was performed in pairs, it would have been relevant to see the outcome of multiple participants' evaluations.

A preference was given to the examples on the cards compared to the description. And while the descriptions have found themselves useful for multiple participants, a redesign of the layout of the cards may be found helpful. This redesign should pay more focus on the complexity level, and maybe switch the description and examples around. However, a larger-scale evaluation would be relevant if making an iteration. This way other, now unknown, problems may be encountered.

8.3 Evaluation functional requirements

The list of functional requirements helps understand whether the product is up to users' needs. The following table discusses each functional requirement and whether it has been met or not, and in which way it has been done so.

Nr.	Functional requirement	MoSCoW	Evaluation results
1	The tool must be accessible through the current Robot Facebook website	Must have	A new page called Design Tool has been added on the website where the tool has been explained and the files can be downloaded
2	The cards should show the State of the Art that is included in the database	Must have	The backside of the cards contain examples of robots of that category derived from the database
3	A description of the showed feature should be included on the cards	Must have	On every card a description is placed that describes that showed feature
4	Every category of features should include at least 4 cards	Should have	Every category contains 4 to 6 cards
5	The database should be updated with at least 5 new relevant robots	Should have	Five new relevant robots have been included on the database
6	Symbols should be added to the cards that show in which main category of the database that features is often seen in	Should have	Every card contains a symbol of in which category that feature can often be seen in
7	The expression sliders are physically movable	Could have	Curtain railings are used as sliders and allow for easy

			movement
8	Users are able to draw on the cards	Could have	The Framework cards have been laminated to allow drawing
9	There is a direct technological connection between the tool and the database	Could have	Only a QR-code is added on the board that directs you to the database. However, there is no technological connection such as a NFC chip.

Table 8: Evaluation functional requirements

8.4 Evaluation non-functional requirements

The list of non-functional requirements helps understand whether the product is up to users' expectations. The following table discusses each non-functional requirement and whether it has been met or not, and in which way it has been done so.

Nr.	Non-functional requirement	MoSCoW	Evaluation results
1	The tool should help provide structure in the process of designing a robot's face	Must have	Multiple participants indicated that it provides a good starting point for designing a new robot face
2	Allow for easy iterations of a design	Must have	There is an easy switching of features due to the magnetic tape
3	Should allow flexibility in usability	Must have	Every participants had somewhat of their own workflow
4	It should help users make informed design decisions	Must have	The description and the expression side help provide information, however less attention is paid to those so it could be improved
5	Should be intuitive to use	Should have	Without providing a lot of explanation on the use of the tool, no participant had trouble using the tool

6	Should be usable by multiple people at once	Should have	The hybrid user evaluation showed this is very possible, and even beneficial
7	Should be easily portable	Should have	The board and cards are rather large, making it not the easiest to carry around.
8	There should be a logical connection to the database	Should have	The examples and symbols are a good logical connection to the database

Table 9: Evaluation non-functional requirements

9. Discussion

The project started as a way to inform users about the analysis and information acquired by the previous graduation project of Eva Velt. And while this was the starting point, the purpose of the project gradually shifted to developing a new methodology of facial robot design. It resulted in a stronger focus on the design part, and a lesser focus on the informing side of the project. This can also be seen in the results in the outcome of the user evaluation. Participants paid more attention to the framework side of the tool, and less to the expression side. Making it better for quick prototyping, than informing users about the acquired data of the database analysis. This also resulted in the fact that the tool is better suited and interesting for users who have no to little experience with facial robot design. Users who do already have experience within this domain may find the tool less useful since they already know the current State of the Art and technological possibilities.

This shift in focus does open up the possibilities to other groups of end-users. For example, people in education that quickly need to know the basic information about robot design. If the project is continued, it will be interesting to do some research about other end-user groups.

Another thing that is relevant to discuss, the is lack of technological connection between the database and the tool. Within the section of the final concept, the idea of adding NFC chips to the cards has been discussed. Eventually, due to time constraints, the decision was made to not incorporate this element, and only add a QR code to the board that redirects you to the database. This lack of connection contributes to a larger gap between the tool and the database. While it is best to use both elements in combination with one another.

9.1 Limitations

Within this research, there have been a few limiting factors that have influenced the total outcome. One of the foremost limiting factors is the result of time constraints. This research has been executed over the course of half a year. While this was sufficient to produce a relevant Hi-Fi prototype, a total product iteration could have helped improve the final product. As talked about in Section 8.2.1, some small fixes, such as adding placeholders for the pens, will help improve the total usability. It would also be helpful to note which cards are more used than others, eliminating cards which are never used and introducing new ones. However, time-wise, making a complete iteration was not plausible to execute.

Another result of these time constraints is the limiting number of new robots in the database. Now only five new relevant robots have been added to the database. However, between the last addition in 2017 and the current year of 2023 more than five relevant robots have been produced. Adding more new robots provides a more accurate overview of the State of the Art, which could have been used in the design tool.

The user evaluations helped to gain insight into multiple aspects of the product. However, only seven participants took part in this research. Performing more user evaluations would tremendously help gain a better understanding of the performance of the tool. Next to the number of participants, the selection of participants could have been

improved. All of these seven participants came from personal circles, such as the study association. And as mentioned previously, the hybrid user evaluation was especially successful. So performing more user evaluations with other, unknown participants and in small groups instead of individual tests, will help assess the product more thoroughly.

9.2 Future work

The developed tool for the Robot Facebook is currently in a good Hi-Fi prototype phase, which is functional for users. However, if this research is continued there are some recommendations which could help the completeness of this research.

First and foremost, it would be advantageous to perform more research on all the elements contributing to robot faces. One of those elements is for example movement. Through the movement of facial features, expression is researched. The current format of the design tool does not explicitly focus on and allow this movement. It would be interesting to do more research on how these factors contribute to the perception of robot faces. Next to movement, there may be other under-researched factors at work to contribute to this perception. Performing broader background research will help put all these factors to light. And eventually incorporating them into the tool helps users make better robot faces, which is the ultimate goal.

The database would benefit from a re-categorization. As discussed in the background research, the current main categorization does not fit into the academic categorization. A critical re-evaluation of the current category use may therefore be in place and help connect the database to more academic sources.

Next to the main categorization, a re-evaluation would also be good for all the attributes. Currently, a very large list of attributes is used for the robots, making the database feel somewhat cluttered. A critical re-evaluation would help see which attributes could for example be combined, or maybe left out at all, contributing to a better and clearer search function.

At last, one recommendation would be to explore ways the database can be connected to the tool. While it has been discussed that for example, NFC would form a good connection to connect the tool to the database, it would be interesting to see how this connection can be formed the other way around. One idea is to incorporate the colour gradients into the database. But there may be many other ways to form this connection.

10. Conclusion

This research has led to the development of a design tool that is aimed at guiding designers in the process of facial robot design by taking The Robot Facebook as a starting point. Literature research has shown the importance and effects of the visual appearance of robots, especially regarding faces. Appearances shape the expectations of behaviour and therefore influence the total user experience. Showing the importance of having a well-suited design. Next to this literature search, design methods such as card-based design, have been explored to find methods how this design process can be improved

By using the knowledge of background research, speaking with important stakeholders and performing multiple brainstorming sessions, a product concept got developed. This concept takes the information from the database, informs the user about important factors of facial robot design and guides them to make a well-informed design.

A tangible Hi-Fi prototype of the design tool was realised. The prototype consists of Framework & Feature cards which show elements of a robot's face. Through the placement of descriptions and examples derived from the database, users are informed and guided into making an informed conscious design decision. The illustration part of each card is detachable through the use of magnetic tape and attachable to the design board. The design board allows for the building of the new robot face. The other side of the design board contains sliders. Through the use of sliders, users are forced to think and make decisions about the level of complexity they want for several dimensions of expression. The cards and the design board together form a new method of rapid prototyping robots' faces in which users are informed in a quick, easily accessible manner.

Evaluation of the tool has proven that the design tool has promising assets that guide users to a well-informed robot face design. Participants enjoyed using the tool and indicated that it helps them make a good design without requiring a lot of background knowledge. Nonetheless, there is still room for improvement. More focus on the informing side, together with a better connection to the database would help complete the tool.

This research is thought to be successful in outcome. It has shown to be successful in communicating information from the Robot Facebook to users to eventually help them make well-informed robot face designs. Something that each new designer should aim for.

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Appendix A: Table of all displayed information on cards

Framework cards

N.	Title	Description	Applications	Example	Symbol
1	Human-like	A human-like face shape tries to closely mimic a real human face. This is a complex shape and should be executed correctly to lower the change of a creepy feeling. This framework often leads to having several human-like features. Human-like robots are most often used in social settings.	High	Sophia Ameca	H-L A
2	Helmet	A helmet-face shape looks like the robot head is wearing (an often white) helmet. This frequently leads to minimally implementing other features. Ending up with a rather abstract face.	Mid	HRP-4 VGC-60L	H
3	Oval/ Round	An oval/ round face is a simplistic shape. It creates a softer, cartoonish face. Other features are therefore also often more abstract. Most oval/ round robot heads only have one characteristic feature. Ending with a soft cartoonish robot.	All	PaPeRo Baymax	C
4	Animal-like (long beak)	An animal-like face shape tries to partially mimic the shape of the ear of a certain animal. One type of animal-like face shape has a long beak, for example dogs. This creates a playful face.	Mid	Aibo Chip	C

		By using cartoonish features, animal-like robots are often seen as cute, and are therefore used as toys for entertainment purposes.			
6	Screen	A screen can be used to mimic an often simple face. These screens are often rectangular TV shaped. They often display big cartoonish features.	Low	Plato Cozmo	C F
7	Undefined (function defines form)	Robots with an undefined face shape are defined by the features and mechanics of the design. The features implemented on the face determine the face. (You could draw an outline later around the features)	All	Chimp PR2	F

Eyes feature

N.	**Type**	**Description**	**Applications**	**Example**	**Symbol**
8	Anthropomorphic human eyes	Anthropomorphic human eyes have a human feel to them, often including things such as eyelids. However, they are not a complete replica. Most anthropomorphic human eyes are slightly bigger in proportion, giving them a cartoonish touch to the face.	Mid/ high	Meka Robotics S2 Icub	C A
9	Human-realistic	Human-realistic eyes are intended to mimic real human eyes. When executed poorly it can create an uneasy feeling. Eyes are an essential feature in the perception of a robot.	High	HRP-4C Rex the bionic man	H-L

10	Oval/ circle holes	Oval holes/ camera lenses are portrayed as two black holes. They often function as a camera. These eyes add a cartoonish feature to the face. Some eyes are actual holes in the face, while others are placed on top of the face.	Low	Aila PaPeRo	C
11	LED	LED eyes are often displayed on a screen and therefore emit light. They are a caricatured version of eyes. Therefore they can quickly take different shapes through changing pixels.	All	Aido Cozmo	C
12	One round eye	One eye in the middle often functions as a camera. Only having one eye leads to a more abstract face, lowering the feeling of a human.	Low/ mid	Jibo Hermes	F
13	None/ function defines form	Humans are good at anthropomorphizing things and seeing faces in objects. Therefore having no eyes can feel odd. However, some mechanics can unintentionally serve as eyes.	Low	Bigdog Chimps	F

Eyebrows feature

N.	**Type**	**Description**	**Applications**	**Example**	**Symbol**
14	Real hair (human-like)	Real hair eyebrows are a replica of human eyebrows. They can play a factor in replicating the feeling of a human, and therefore should operate on the same level of complexity as the eyes.	High	Ibn Sina Jia Jia	H

15	None	A large portion of robots do not contain eyebrows.	-	Nao Pepper	H C A F
16	Abstract dots	Some robots have small dots above their eyes that can be considered as eyebrows. They could serve as cameras. This feature adds a playful cartoonish feel.	Low	Romeo 2 Paro	C
17	Anthropomorphic shape	Anthropomorphic shaped eyebrows have a human shape to them, however, they are more abstract in the sense that they do not feel real. They are often plastic and add a cartoonish feel to the robot.	Low/ mid	Icat Flobi	C

Mouth feature

N.	**Type**	**Description**	**Applications**	**Example**	**Symbol**
18	Anthropomorphic mouth (with lips)	Anthropomorphic mouths have a human-shaped mouth, often with lips. However, they do not feel real in the sense that they are of hard material. They are often combined with anthropomorphic eyes and eyebrows.	Mid/ high	Flobi Kobian-RII	C
19	Beak (bird)	Some animal-like robots have a beak-shaped mouth. There are several types of beaks, and one of them is pointy bird-like. However, there are also other shapes. Note: not every animal-like robot has a beak-shaped mouth, often other mouth features are used.	Low	Hatchimals Furby	C

20	Carved (line carved in frame, does not move)	A carved line through the face can serve as a mouth. A large portion of these mouths do not move and are in a smiling position. Giving the robot a more kind appearance.	Low	Kotaro/Kojiro Manav	C
21	None	A large portion of robots do not have a mouth. This gives the robot a more abstract appearance. This does not imply that the robot cannot make sounds. However robots with no mouth often make sounds that are not words.	-	Meka Robotics S2 Lovot	H F C A
22	Human-like	Human-like mouths are intended to look very realistic. And are therefore often soft to the touch. They usually move during speech.	Mid/ high	Alice Sonny	A H-L
23	Projection/ Screen	Projected/ screen mouths are digitally displayed on the face. Often through a screen. This makes them very flexible in use since they can quickly take other shapes.	All	Icub Plato	C

Ears feature

N.	Type	Description	Applications	Example	Symbol
24	Abstract	Abstract ears are often circular disks placed on the side of the head. Most don't have a real function apart from appearance. They could provide structure to the facial shape.	-	Surena 3 Walking Trumpet Harry	H C

25	Animal like - hanging	Animal-like ears can take multiple forms. One type of animal-like ears are big hanging ears. They are often used in dog-related robots.	Animal ears can contribute to the expression of the robot. They could function similarly to eyebrows.	Aibo ERS-7 Aibo	C
26	Animal like - pointy	Animal-like ears can take multiple forms. One type of animal-like ears are pointy ears, often placed on top of the head. They are often used in bear-related robots.	Animal ears can contribute to the expression of the robot. They could function similarly to eyebrows.	Furby DARwIn-OP (ROBOTIS OP)	C
27	Human-like	Human-like ears are intended to look as realistic as possible. They often don't have a function, apart from appearance. However they contribute to shaping the facial shape.	-	Geminoid DK Sophia	H-L
28	None	A large portion of robots do not contain ears. This leads to more abstract design.	--	Uxa-90 AILA	H C F A

Nose feature

N.	Type	Description	Applications	Example	Symbol
29	Human-like	A human-like nose is intended to look realistic, in order to make the robot appear more human. Apart from appearance, it usually doesn't have a function.	-	Nadine Actoid	H-L A

30	None	A large portion of robots do not have a nose. This can contribute to a more playful cartoon design.	-	HOVIS Eco Buddy	C H F
31	Dot	A black dot, often in the center of the face can be perceived as a nose. This dot often does not have a function.	-	Lovot Keepon	C
32	Anthropomorphic	Anthropomorphic human noses have a similar shape to human noses, however are often not of a realistic human color and material. They are also often less defined.	-	Robo Thesian Flobi	C

Appendix B: Transcript Expert Interviews

Red questions are questions that were thought of during the interview.

Interview #1

General questions on design tools	
How familiar are you with social robot design?	I have followed the course social robot design last year. So most knowledge comes from there on this. I also followed a course on human-robot interaction, which is also a part of social robot design. That is mostly it. Trans in human-robot interaction is mostly about what research has been done on human-robot interaction. So on categories, safety. You also have to write an introduction background and methodology for the research you can perform. You will not really do this research but only write it. So thinking about how to do research on what works for social robots and what doesn't.
Are you familiar with design tools? *Yes → which ones, and in what kind of projects did you use them* *No → provide examples as explanation (Brainstorming tools, scenarios, personas)* *Especially question about brainstorming*	I am mostly focused on the design part of projects. I use storyboards quite often in those cases. During brainstorming however not really. I do use scenarios and customer and user journeys to find the user requirements.
When (or would) you make use of these tools? *Would you always use them or maybe if*	I use those tools pretty much every time.

something in the process got stuck	
Do you think these tool help during the design process?	Yes because it helps to think about a problem or context differently. So apart from what only see by yourself, and that very precious. Especially when you design for a target audience which you are not familiar with or not close to.
Following questions are more specific on the tool for The Robot Facebook	
Where would you start when having to design a face for a social robot?	I would start with getting to know the context and the user. Who are the involved stakeholders. So in a hospital it is not only the people who use the robot, but also the people who work there.
What are the other steps? *<Maybe provide examples>* *Inspiration* *Ideation* *Implementation*	And then approaching it from all perspectives. This connects well with the scenarios, personas and customer journeys. I also think its important to involve the user during the process. So after first doing your own research and then continuing with for example interviews. Or using other ways to find out what the users think is important, there more ways to do that apart from interviews. And from that drawing conclusions and making iterations to the design. So making one thing, but keep asking feedback from the user.
Which are the hardest parts of this process?	Uhm.. this a quite hard question. People say something while they need something else. I think that is quite relevant in almost every design project. Sometimes I find it hard to see what is relevant. You can go very broad with a large range of options, for example in shapes and sizes. But I think also depends on how the problem is formulated.
Do you think a tool would help in those parts?	Maybe something like a state of the art. So search for example a certain application, this user group and what they did and why they did that. So it becomes easier to search that since that is quite hard now. Instead of really looking for a paper that describes which shapes are more friendly.
What would this tool have to do for you?	Yeah, making the information quickly accessible.
What kind of information should be	Context and target audience. Context as in where the robot will be used. But also form of interaction. Which input do you give, for example type of communication. Physical attributes such as

incorporated into this tool?	shapes, sizes, voice, sound are also quite important. So seeing what works in which context.

Interview #2

General questions on design tools	
How familiar are you with social robot design?	Facial robot design? Well, not so much familiar. Robot interaction mostly. So, not so much even the design of it rather than the probing. What can we do with it and what does it mean? And in that respect, it was also part of setting up the master course social robot design you probably know.
Are you familiar with design tools? *Yes → which ones, and in what kind of projects did you use them* *No → provide examples as explanation (Brainstorming tools, scenarios, personas)* *Especially question about brainstorming*	I'm currently working with movement based design, which is a different direction that might even be interesting. Also for the for the robot Facebook I'm thinking about it, but that's more about using your body as an inspiration and your body function. So taking movement as inspiration. Also during design, so do you do take active part in brainstorming rather than just brainstorming and sitting, but also using the context where you have an active element in that? I also think when I'm working with students that this is being at the situation. So being in a situation and knowing what kind of context you are working with, doing observations, I think that's an important tool that we use. The lenses of design are interesting. The design thinking toolkit. Especially the design thinking phases And another two is, is design spaces. So we created the design space for sports interaction technology. So you what you are doing is basically also helping to facilitate the design space. So how should it look, what kind of options do we have and other parameters such as facial expressions, like the kind of attitude that you do.

	It is also better trying to split up your design problem in components. For instance, if you have a phone, there's some sort of need for power, there has to be some sort of feedback and some sort of input. You could have all different kinds of inputs, or basically we do everything that it could come up with a speech only input or speed sensor. And and eye tracking input. So you split up all the components and you come up with different kinds of concepts for that. Part and then you can combine in creative ways how you how, how the whole thing would look like. And by that you have a sort of creativity tool. Hard form as well. So we have a database of 100 sort of small methods or techniques written out on a card where you have a combination of OK, So what would you do? How would it look like? What kind of variations can you do on top of it? That might be separate cards with the specification on the card? And then some background information about references etcetera.
What is important in these type of tools?	I think providing overview in general in a very short way so that you can familiarize yourself with the things that you want to use and that you could use them in a superficial way really quickly. But if you want to dive into them, let you know also how to get there, so sort of.
When (or would) you make use of these tools?	-
Do you think these tool help during the design process?	-
Following questions are more specific on the tool for The Robot Facebook	
Where would you start when having to design a face for a social robot?	Yeah. So basically the the design thinking part. So they empathize with what is the context that we're working in, understanding what the real issue is. So that to emphasize this both to talk with users, to observe them and to talk with the experts that talk with users often.

What are the other steps? *<Maybe provide examples>* *Inspiration* *Ideation* *Implementation*	Then you go into its defining the the problem statements, but also the opportunities that are there. That's also already goes together with the ideation phase of because of the technological opportunities often also find different kinds of ways to dive into the problem statement and know where it can really help with the start. It depends a bit on how the assignment is. Yeah. And then then it's designing things and based on the design, you also have to tailor your testing, whatever kind of statement you want to make. And sometimes at the end, it also means involved in the companies that might take that up to the next step.
Which are the hardest parts of this process?	
Do you think a tool would help in those parts?	
What would this tool have to do for you?	Bit of both things. So it's indeed a linking to maybe the knowledge next to the like the related work, right? So that's always something that's doing thinking about the problem statement and the kind of ideation opportunities that you can step into. But it's also like a mood board and uh, like a persona that you create so you know what kind of things you want to do. So because it's so concrete, if you talk with stakeholders like, OK, where do we want to go with, then it's pretty clear to have some broad example set to get into the conversation. Rather than have to explain what parallel is, you can just go to the place where the robot Facebook and show it.
What kind of information should be incorporated into this tool?	

Interview #3

General questions on design tools	
How familiar are you with social robot design?	I did not follow the social robot design course. However, I am busy with research about social robots in interpersonal closeness. So I am quite busy with that. The course is about the research behind the design of the robot. What are things that are important within the process of making such a robot?
Are you familiar with design tools? *Yes → which ones, and in what kind of projects did you use them* *No → provide examples* *Brainstorming tools, scenarios, personas* *Especially question about brainstorming*	For me there is a difference between if you do it at the university or not. If you make it completely on your own I would use different tools. Answer for brainstorming: I like starting with writing all my thought down on a board, and from there seeing patterns of things that reoccur, and choosing from there.
When (or would) you make use of these tools? *<Would you always use them or maybe if something in the process got stuck>*	I use those tools standard since I have the feeling that I gain the most from those tools.
Do you think these tool help during the design process?	-
Following questions are more specific on the tool for The Robot Facebook	

Where would you start when having to design a face for a social robot?	I would start with looking for references. Looking at what I can find online. By doing that you can most of the time already narrow down what this robot could potentially look like and what you need. It is really important that you take the specifications your client gives and use them in this research. So looking at the unique combinations what the client want and from there seeing what could work. First doing research yourself and from there linking it back to the user
What are the other steps? *<Maybe provide examples>* *Inspiration* *Ideation* *Implementation*	-
Which are the hardest parts of this process?	I think it would be helpful if there would be a central point where you can find the same kind of information. Right now when you go online there is a different kind of information available for every robot. Some are more technical than others. You already have a clear list on what you think is important. so the filter in the pre-research. If that could go quicker that would be really helpful.
Do you think a tool would help in those parts?	-
What would this tool have to do for you?	Having a standard list of specifications about a robot, and that is the same for every robot. That makes it easy comparable. So a database in which that is easy.
What kind of information should be incorporated into this tool?	By having all these robot close to you, it makes is easier and quicker to make certain design decisions. Instead doing a really long background research, or being limited by the robots you know you would get a limited view. By having guidelines it would be much easier

Appendix C: Robot case scenarios for user evaluation

One of the case scenarios will get given to the participants of the user evaluation.

#1 Companion healthcare robot for the elderly
This robot serves as a companion for elderly people. The robot will not perform a lot of complex physical tasks, it is more focused on being a companion. However, it does remind the user of certain things through speech. For example, it will remind the user of taking particular medicine or tell the time of certain activities that day. The users should trust the robot, and allow the robot to stay in their house. It will move around, and sometimes follow the user, and therefore should not look creepy. The robot should display emotions the elderly can recognize.

- Design for elderly
- Users should trust the robot
- Display easily recognizable emotions
- Big company, budget not a concern

For group B:
Feedback from client:

- Design is currently not expressive enough
- Didn't like the human-like style

#2 Security & information robot
This client wants a robot that will perform mainly security tasks. So it will have a fixed position, and observe the outside through a camera. This camera should be able to look around. AI software will analyze the security footage, and a signal is given to the system when something suspicious is observed. When this is the case, the robot itself will do nothing, apart from alarming silently. Next to this security task, the robot should be recognizable to people as a sort of information point. People can ask for assistance through the robot with certain buttons.

- Recognizable as an information point
- Emotions not necessary
- Include camera
- Medium budget

For group B:

- Too complicated design
- Feels kind of creepy
- Really likes camera placement

#3 Movie robot
This client wants a robot that will star in a new cyborg movie, so it will not be physically built and only animated on screen. This cyborg should mostly look like a human but it should include some technical parts so the viewer knows it's a cyborg. The character of this robot is calm and confident. Emotions are an essential element of this robot, and therefore the design should allow for a large range of options.

- Movie robot, so not restricted by physical laws
- Mostly human
- Large range of design possible

For group B:
- Not human enough
- Can be more unique
- Needs to allow for more head movement

Appendix D: Transcript User evaluations

User Test #1 (Case scenario #1 Healthcare)

Observational remarks

- Eliminated options based on the scenario
- "*I will pick the round framework because it is most trustable*"
- Random order of picking features
- When dealing with nose feature, made the comment "*Oh there is no nose slider*"
- Checked whether all the steps explained on the board were done
- The level of complexity of the framework is on the back, so lift everything up
- Gradients could have been more drastic

Interaction time: 16.41

Interview Questions

Questions	**Answers**
Could you talk me through how and why you made that design for your case?	I chose the overall cartoonist style because from the description I thought we want to have friendly yet human-like features and like the big card (human-like framework card) said that the human appearance can be quite creepy looking. So let's go cartoonish so I included, except for the nose, all the features that have a human-like appearance
What was your way of working with the tool? Was there any reason behind the order of picking the features? What was your way of working with the expression part?	Well I followed these steps (steps explained below on the design board) on the framework, and I first selected a framework card and I went from the bottom of the head to the top. So first mouth and nose, then ears, eyes and eyebrows. Not really, I thought it was nice to go one way or another and I think for this example the mouth is one of the most influential parts. So it was important to have a good mouth and paste the rest of the design around that element. I think I did not quite use that part because I did look at the complexity levels on the bottom of the cards, however, I only just read it and ask myself whether it fits what I'm going for. So I did not translate these thoughts to the actual sliders.

What was your initial reaction to the product?	I think it looked nice, especially the wooden frame. The colours around the cards also sparked my interest and are aesthetically pleasing.
When was it clear to you what you could do with the tool?	One thing that I noticed was that the nose was missing from the expression sliders, so that made me wonder why that one was missing. Other than that I think it was quite clear, or at least the framework. As I said, I didn't think I used the expression part correctly, I guess there was some other meaning behind it.
Were you able to make the design you had in mind for your case?	Yeah, in my opinion, I made something that I intended to build.
Were there enough options available? *If not, what were you missing?*	No, I think there are quite a lot of options, but not so much anything missing
Did you make use of the information and examples on the cards	I mostly focused on the illustration part of the cards. I noticed that reading all the cards took quite a lot of time, because the text itself is not that big but looking at all the cards together, yeah it is a bit big. I didn't really look at the back, I honestly didn't immediately know that there was something there. -
Was the concept of the expression sliders clear? Could this explanation be improved?	I think the concept behind the expression sliders was to visualise and keep track of the expression you chose. I did that all in my head, like okay yeah I have *Mid* there, and *High* there. I built the robot in one go, but I can imagine if you are not happy with the result, for example, the mouth is not the way I wanted, it is handy to use the sliders instead of doing it all in my head.

	Yeah maybe add a section on why you would want to use the expression. Because I didn't really feel the need but with some explanation maybe I would.
What do you think of the design of the board?	It looks great!
Do you feel confident you can make a good design with this tool without requiring a lot of research?	I think the only thing that's lacking is for me if I could mix different features. Like I said I only have the C (Cartoonish) features because then it all fits together. Yeah, I don't know if it's quite possible to also include the human features with the cartoon if that's allowed. I can imagine that you can only place it with an LED mouth on a screen. So some more information about the possibilities but other than that it's a nice tool to just play around with.
Are there any things you want to see improved/ final remarks?	The magnetic tape isn't that strong, so there is a high chance of losing the illustrations. So maybe some form of indication of which illustrations and cards fit together.

User Test #2 (Case scenario #2 Security Robot)

Observational remarks

- They place the options aside but don't try to stick them to the board.
- Ignore expression, at the start,
- "*There are a lot of eyes*"
- Wonder what head operation entails
- Take illustrations as an example, but draw them on the board.
- Really think about the interaction and movement of the features

Interaction time: 20.42

Interview Questions

Questions	**Answers**

Could you talk me through how and why you made that design for your case?	S: Based on the scenario, emotions aren't necessary, should include cameras and a medium budget. It is kind of simple, it is just a screen, without many emotions, however, it does feel like something is watching you which helps with the security thing. And because of the giant info button on there, and I guess there is a face, so, therefore, it is approachable as an information point. All of the things included have a function. The ears are speakers, the eyebrows are the camera and the mouth is just to convey a level of information. B: The screen could also be used to display something else. S: It just moves around the room, or scans the room. B: There is no further movement necessary from the head, so it only turns around. It is about as big as 1.60 in total, so it is not too big to be intimidating but big enough for people to see it as a robot or human to approach for information. And I think that is it.
What was your way of working with the tool?	S: First we looked at the general shape we wanted to do. And kind of connecting it to what the scenario said. I think then we just went through all of the cards, so ears, eyebrows, eyes, mouth. Again combining it into the scenario. The expression was quite easy in this scenario because it said it doesn't need a lot of emotion. So the sliders are all on the left side. We didn't really use the gradient. B: No we didn't, but we did use the symbols. To look at the cards which could be useful to use. Even though we ended up with something cartoonish in the end. S: Yeah we kind of did B: However I didn't think that was a problem. We also looked at the examples on the back of the card. To see whether we recognize those robots and what they are used for. So that helped a lot to see which features we wanted to add to the robot. And the different sliders how much we needed every part to operate, and forces you to think about that. Otherwise, you wouldn't go through it step by step. S: And at the end, we did look at the expression sliders to see whether they fitted the face we made.

	B: It is a good reminder to check the different features.
What was your initial reaction to the product?	S: For me, it was the fact that I could draw on the cards. It is tangible which is always nice. There are a lot of choices, which is a bit overwhelming at first but when you read it all and go through it all it gets clear. B: But there is a clear overview. The first thing that sparked my interest was the different parts of the robot's features. Mostly the eyes, it wanted to go through the different cards to see which cards there are. S: It might be nice to remind people there are examples on the back. In the end, I knew, but a small reminder could help on the cards. Or have it somewhere on the board. B: I totally forgot to look at the gradients. S: Yeah, the gradients are kind of difficult to compare.
When was it clear to you what you could do with the tool?	B: Yeah for me it was clear enough how I could use the tool. After you explained and looked at the different parts and how they connect, it was really clear actually S: It is nice that it is so customizable. We only used some illustrations on the cards to actually stick to the design. However, I did take inspiration from all the cards to draw them ourselves. It is nice to have something physical B: If this was a more digital tool, we would have actually used the illustrations on the cards S: I liked the fact that it was not digital. It sets you more in a creative space. For me, it is always helpful to have something tangible and be able to move things around.
Were you able to make the design you had in mind for your case?	B: I think so.

Were there enough options available? *If not, what were you missing?*	B: Well, we used for example square eyes instead of round eyes, so maybe those could be added. But there are already a lot, so I think there is enough to get you into a creative space. S: It is a nice base. I mean there are so many possibilities, you can hardly print them all out. And like I said, it is nice that it is customizable. You can take the cards as examples. You do need some knowledge of what robots look like. I knew one robot from the examples, so I knew how its eyes moved, which gives a nice effect. So it is helpful to have some previous knowledge about robots. But it is a very nice base. B: You could for example state underneath what they are used for. B: The tool is definitely a nice base to build your own robot.
Did you make use of the information and examples on the cards	S: I scanned through most of the text on the cards. It first looked at the examples on the back, and then scanned through the text. And sometimes I saw certain words in the text that we needed for our scenario. B: We specifically chose these eyes because they are displayed on a screen. It is said in the text of these eyes that is possible for these eyes. And some with the mouth.
Was the concept of the expression sliders clear? Could this explanation be improved?	S: It is just a way of reminding yourself how much expression you want and if it fits the robot. So I think it is clear enough.
What do you think of the design of the board?	S: I like the design of the board. it‘s spacious, maybe if it's plastic it will be cleaner. I mean the wood is a good thing for now, but if you scale it up to a more production scale that would be something to consider. And the design is quite clear.
Do you feel confident you can make a good design with this tool without requiring a lot of research?	S: Yeah definitely. If I was tasked with making a robot, I wouldn’t think I would come up with this. Maybe at the end, maybe through a lot of iterations. But this is a really good starting point, I think.

	B: I think so too. I think the design looks professional enough for the purpose of this scenario. S: I can visualise it now in my head, and I think that is really valuable when brainstorming about a design. B: I can actually see this design implemented.
Are there any things you want to see improved/ final remarks?	S: Not really I think.

User Test #3 (Case scenario #3 Movie robot)

Observational remarks

- Really take the time to read through all the cards
- Make a comment about that it shouldn't be too Uncanny Valley
- Flip the framework to see the level of complexity.

Interaction time: 8.06

Interview Questions

Questions	**Answers**
Could you talk me through how and why you made that design for your case?	The scenario said it was a cyborg with mostly human features. So that's why I picked these very human-like features. But to add to the cyborg part, I think hair-like eyebrows take away from the cyborg likeness. I think having abstract ears could be a nice effect. And in addition, the light-up lines that could convey emotion are I think very robot-like. But I think that is a good mix of both. Also thinking about emotions is an essential element. I think the eyes and mouth are very influential and very important for expression. The nose maybe not be so much, but having most of the features being human makes it coherent and less creepy. Compared to something that has only human eyes and is very robot-like the rest. And I was looking at the level of complexity, and since it is not restricted by physical law. These features being very human-like is difficult, but animating them can be less tricky

	than having them physically controlled. So that is why I picked all those features.
What was your way of working with the tool?	I first wanted to start with the base. In my head, I was also like I can switch around if I have to. But I wanted to start with a human-like base because of the assignment. And the base is just easier to think of the different features you wanted to use after that. And I am not sure why I did the order I did the features in. I just picked what came to mind. And really going back and forth between the assignment and the tool. In order to make sure I am following the assignment correctly. In the end I was like I should put the sliders in the right position. And I just looked at the cards and the gradient. Because that was a little easier to see. In the end I didn't use the symbols, mainly just the title on the cards, that was enough. And I only used the examples on the back once when I was kind of stuck with the mouth. I wasn't sure which one to pick. So that was also helpful.
What was your initial reaction to the product?	The movement of the sliders drew me in at first. So that was my main focus point first. Then I went over the cards because they are all colourful. And you are like oh you can take parts of the cards off. And then I think of the framework cards.
When was it clear to you what you could do with the tool?	Yeah it was clear enough. I think it is nice you get direct visual feedback whether parts of the design fit together or not. And you can then keep checking with your assignment if it is correct or not. I don't think you need very direct steps, it is nice you leave people free to do what they want first.
Were you able to make the design you had in mind for your case?	You pointed out you could draw. At first I wanted a see-through head that I saw in one of the examples. But that is very hard to put on the card. So drawing really helps, because in that way you make the options you have in mind when they are not on the cards
Were there enough options available? *If not, what were you missing?*	-

Did you make use of the information and examples on the cards	I did make use of the examples, but I didn't read the text on the cards. I think I was more interested in looking at the examples. When I first went looking through the cards I was turning them over. And I much rather go off my feelings and intuition than reading the text.
Was the concept of the expression sliders clear? Could this explanation be improved?	I think the concept that it matches eventually with your design was clear. But maybe why you would want to see this in a slider form. Why would you want to know about expressions? I can think of things, but that wasn't immediately clear to me.
What do you think of the design of the board?	Kind of depends on what you want. Because now I did the expression sliders at the end, and not while I was doing it. So the framework was my main focus and seeing what would fit together. And the expression was more of an after-thought. I can also imagine if the expression and the complexity of it is the focus, you first explain about expression and then you go on with the design.
Do you feel confident you can make a good design with this tool without requiring a lot of research?	I think making something that looks good or would fit the description, yeah that is definitely possible especially because you can just try stuff, erase stuff and switch things around. With this trial and error you eventually come up with something nice that fits the assignment. But understanding what everything does for the expression and for the conveying of emotion might be missing. I think you can make a good design, but I might just be lacking a little bit of understanding. I think you would need to explain the idea of how expression works, and what it is based on, and what components there are. But it also depends on your target group whether they want to know that, or if they just want to make a robot.
Are there any things you want to see improved/ final remarks?	No, I can't think of anything.

User Test #4 (Group B Healthcare robot redesign)

Observational remarks

- Takes everything of the original design to start completely over
- Really uses the descriptions on the cards
- Easily switches features around
- Connects sliders with a scenario and at the end checks if it matches the design

Interaction time: 11.50

Interview Questions

Questions	**Answers**
Could you talk me through how and why you made that design for your case?	I wanted to stay away from human-like things. Because it's also I guess, a personal preference. But I, you've probably heard of Uncanny Valley. Yeah. That's not good. I think anthropomorphic human also like, borderline-like, Uncanny Valley. So I definitely think these kinds of anthropomorphic human. It tries to be a human, but it's clearly not. And I think, for elderly, that might not be nice, because then it might take some time to adjust to the fact that it's kind of creepy looking. I think it always looks creepy. And I think a robot that has like, when you hear like motors, and then you hear like the motors, because it's like, it's physical (mechanic). Yeah. So then you hear the motors, and you see it adjusting. And I don't think that will be a good fit with the elderly because that's really on-the-nose technology. And of course, this is that as well. But they're also used to, well, TVs, maybe also computers, probably right now, most elderly also encounter computers, or maybe have iPads or something. So then the screen is not that scary anymore. And it is less like new technology. So that's why I chose a screen. And then having to combine a screen with like physical mechanic stuff doesn't work in my opinion. Maybe it can kind of work, but not as I can imagine for now. So then it was also an easy choice to like, go for like the digital-looking eyes and mouth. And also because it's easy to create expressions with it. And then the ears were just like, sort of like a bonus, like an extra but it's another like human recognition points. To have it, you have to have ears. Yeah. Okay. I think it's what's my entire design.

What was your way of working with the tool?	I, of course, didn't work with it before so everything was new. So that's why I decided to just take everything off that was on there, except for the for the like frame of a face that was on here. But like the eyes and nose and a mouth took off. Because it's like, Okay, let's start from scratch and just like, like, slowly go through the process. So I think I started out by looking at the mouth or the eyes, I think, or the head shape? Well, either of those, because I felt like those were really expressive. And that's really important. I think that sets the tone for the entire robot. If you have a realistic looking mouth, then you're not going to have really empty eyes, for example dots. So I was like, Okay, let's start somewhere over there. And not like ears or something, because I think you're just like, kind of a bonus to your down design. It's not really there, for expression. So I think, yeah, so this was why I took everything off and just started from scratch. And I could just go at my own pace, looking through everything because I had to read everything. And it was all new, like what kind of eyes you have, if you work with it longer than you know, which is you have your options, you know, so then it's easier to mix and match. So yeah, I think that was why I started off
How did you tackle the expression part?	In the beginning, I left it as it was. If I designed something normally I'd kind of like an idea in my head. And then I make it and then I see if it works. And I in this case is working with a framework first and then with the expression part. So I did design, like keeping in mind the guidelines that I got that it had to be really expressive. And I already like that I didn't really look at the bottom text on the papers with a complexity level. But I was like, okay, a digital mouth can do everything. So probably a lot. So that's why and then I read it and I was like Oh nice. It also matches.
What was your initial reaction to the product?	Well, like, from the boards is the stuff that you can interact with. So I can see that you can take this off and move around. And I see it because you can move this around. So that's what pops out most. And also, because it's a different colour, of course, but normally, you won't have this.
When was it clear to you what you could do with the tool?	Yeah, the entire framework was really clear for me. Then I read that you're able to draw with a whiteboard marker. And I was like, why would you do that? Because you already have a lot of

	options for stuff because at the end, I did use it. But it gives you some more freedom with it. Like if you read it. At first, you're like, why do I need to for you? Because it's so customizable already. For the expression I was curious because in the beginning I didn't read the scenario, and on the cards it already shows the complexity and stuff, so why do you need it. But I, I kind of get for now that it's for a nice overview to see if you match with the scenario
Were you able to make the design you had in mind for your case?	Yeah, it depends on what kind of level of design you want. I think for now, if it's like, if it's like, really at the beginning of a project, you just need to decide what technology you're kind of gonna use, then it is a good tool. But if you're gonna work more in depth on the design, then yeah, I want to also within the screen options of the eyes I want to choose different kinds of eyes.
Were there enough options available? *If not, what were you missing?*	I think right now it just says a square screen which I get. But for robot design a lot more can be part of it. So it can be like a round shape. But I wouldn't like a square screen, so maybe that. If it is round, it feels like a friendly, round shape. And that was not an option for now. So I really, early on decided like, Okay, I want to have a screen. But this was not what I had in mind. So I had to work with what I have. And I think the eyebrows were like, not a lot of options. And if you go for a screen there are no eyebrows that match.
Did you make use of the information and examples on the cards	Yes, sometimes. I think if I did want to know more than there was text and it was nice. But I really liked the example samples in the back. It gives you more of like, Oh, of course a furby has a beak and. Oh, yeah. It kind of makes more sense. So I think the pictures are a nice addition.
Was the concept of the expression sliders clear? Could this explanation be improved?	Yes it was but something that was confusing was the different use of expression and complexity. I think maybe you can just rename this, for example, like the expression level and like the same as here. And then right now, it's like expressions and you have complexity. Yeah. And after a while, you can make the connection that this is the same, but always you have to read the text. That explains the complexity. So maybe a better connection between those would help.

What do you think of the design of the board?	Overall it is really nice, I think because when you look at it, it's not too much to look at, and it does not feel like too much text because it's like, it got a break over here. And it's here. It's nicely numbered. Yeah, so I think it's not too much. It's pretty clear and the layout is really nice.
Do you feel confident you can make a good design with this tool without requiring a lot of research?	I think so. If you do like research here for some course or something, and you have to, like, design a robot. Then you have to do some research. Literature then you learn about oh, so maybe for elderly people this can work better and now it can already like explains here with like, the complexity of course, so you don't have to really do some research into the technologies and options and what's like what different technology like offers you so what screen can do compared to like realistic looking eyes, you know, so I think that's really nice, it skips some research parts for you. That's really nice. Because research is often not the most fun part.
Are there any things you want to see improved/ final remarks?	-

User Test #5 (Security robot redesign)

Observational remarks

- Really focused on the complexity levels at the bottom of the cards
- Use information on cards to explore multiple options
- Set outside elements of the first design that were liked to keep them
- Felt the freedom to set the sliders to a level independently from the complexity levels of the cards

Interaction time: 7.33

Interview Questions

Questions	**Answers**

Could you talk me through how and why you made that design for your case?	Yeah, sure. Um, so I started off with the head. I chose the screen because I think it looks kind of neat. So like, a security guy wouldn't be very nice and giggly, but instead a bit more serious maybe. And the same for an information point. And I think people often recognize screens as information points. Um, I think then I went on to the mouth. Because I think the mouth and the eyes are most important for the face, apart from the shape of the head. You can talk to an information point, so I wanted to have a mouth but have it too complex. Because that makes it kind of creepy And I think the same decision was for the eyes. I went for kind of simple eyes. That could still show you some kind of facial expression, but not really too complex for human life. I chose no nose and no eyebrows, because I think it's not needed. It doesn't need no emotions. And yeah, it would only add more creepiness. And then for the expressions, I went for a high operation, because I think it would be nice to be able to have them look around kind of look at you while you're walking to them and stuff like that. So it's clear, you can talk to them. Mouth and jaw operation middle, because then it's kind of clear that you're talking to them, but it doesn't need any more than just open mouths and closed mouths while talking. And eyebrow operation. I don't have eyebrows, so that's not needed. Head operation. I think the conversation is not needed before the security part, it is needed to be able to kind of look around.
What was your way of working with the tool?	Yes, I started with the cards, especially with the framework face. Then went through the most important eye features for me. So that's like my mouth and eyes. And then I ended with the expression.
What was your initial reaction to the product?	I think in general, the face that was already laid out because it makes it very clear like okay, we're gonna build a face here. As well as the sliders. They really stand out also because they're in 3D. And just a lot of cards, but yeah.
When was it clear to you what you could do with the tool?	I think in general, yes. I asked you about the pen, for example. But I would have guessed that that was okay. I only forgot about the other side of the cards with the examples. And also the symbols. I kind of forgot that that was a thing.

Were you able to make the design you had in mind for your case?	Yeah, I think so. I was just thinking about simple stuff. And there was some simple stuff. So not anything that I noticed was missing.
Were there enough options available? *If not, what were you missing?*	-
Did you make use of the information and examples on the cards	Um, I think especially for me, the complexity was useful. Because that's hard to see through the picture. And I think the rest kind of make sense. So, yeah. I think that the most of the text I thought of myself, yeah. But I think that also depends on how many robots you've seen. And, yeah, but I didn't really like the complexity, because that's something you couldn't get in any other way.
Was the concept of the expression sliders clear? Could this explanation be improved?	I think for me the expression sliders were two separate decisions. And because also, like, I went here for low complexity, while here, I went for high movement, which was kind of two different choices. Although maybe they don't even fit together. Like, if you look at the backside of this card, it's just some black side. So probably, it wouldn't even be able to do many operations. So it's kind of two separate decisions in my head, I think.
What do you think of the design of the board?	Maybe you could add someplace where you place the pen. So to make it clear that it fits, it belongs to the board, and it's not there by accident. But for the rest, I think it's really clear. I like the fact that you bolded, some things that make it stand out, and just have here the overall steps so that you are drawn towards that first.
Do you feel confident you can make a good design with this tool without requiring a lot of research?	yeah. I think in general, especially like, if you take some more time to maybe look at all of these even longer, then I think it's quite easy to make a good design without really knowing much about robot design at all. And maybe you could even like it because it's probably going to be in, like in cooperation with someone else. So you could send this and be like, I chose these eyes and his mouth because of this.

	Because I think that's important that I don't necessarily want, especially this mouth, but more this is the reason because then they can do something else with it if they want, but it's Yeah.
Are there any things you want to see improved/ final remarks?	Yes, I just think it might be a bit much when looking at it first, it's maybe not a problem, because you are designing a robot which is a lot. So if you do it on their website, it's going to be even more. And it's a lot less overwhelming doing it in this way, where you just have like choices of the categories, but still with quite a lot. So maybe I would have left this out (the symbol card), because I think it doesn't add a lot because you can actually see it yourself that they look a lot like a human or they look a lot more cartoonish and that removes a bit of the information overload. And the same I think for this one, the gradients. Maybe for some people, it will help but for me, it didn't. The border is nice to see you like oh, these are the ears for example. That's what I was used to colours for and I think you should definitely keep those colours. But I think for me the gradients didn't really do it. If you would remove these two cards it would help with the information overload.

User Test #6 (Movie robot redesign)

Observational remarks

- Random order picking of features
- Start with one category, namely human-like and really use symbols for that
- Make use of text on cards and therefore link complexity eyes and eyebrows
- Easily switch around options

Interaction time: 8.38

Interview Questions

Questions	**Answers**

Could you talk me through how and why you made that design for your case?	Yeah, so I started off with having everything as human-like as possible. So I searched for, especially cards with human-like symbols. So the H L. And then I thought like, okay, doesn't have to be completely human. So it still has to have like a certain level of robotics in it. So I thought, let's change one of the aspects to something more robotic, but still anthropomorphic. So that's why I chose the eyes and the rest is all very human to still convey the human-like, robot. And then for the expression, I put the eye operation on very high, because I feel like the eyes are very good at expressing emotions, or a state of mind. And then the mouth and jaw, I could lower because I feel like that doesn't make as big of as big an impact as, for example, the eyes, the eyebrows are a bit higher but not as high as the eyes. So that you still can move them, but I don't think that they need an extensive amount of expression. And because of the scenario case, I put the head operation also on high because they stated that they needed more head operation.
What was your way of working with the tool?	Yeah, so I went per category. So first, the head, and then the mouth and everything. So I went through all of the features. And looked at also the examples. So to really get an idea of how they are used in real life. And that made me choose or maybe pick all the human-like together to create this. For the expression, I did see that some cards state they need to have the same level as for example eyes. However, I made more of an independent choice to put them at certain levels.
What was your initial reaction to the product?	I do really like the fact that you really get to pick out all the different parts. The only thing I did find is that I was very much looking into which parts match. Which aspects match together? So to create one. But I do really like it, I really liked the fact that you can just build it together and really put your own spin on it. I really think that if this leads to an actual robot, then I would really say it's useful if you use robots in a daily matter.
When was it clear to you what you could do with the tool?	I do think it's very easy to understand because I think it's in our nature to try and create this face. So it's really easy to understand like, Okay, you have one mouth here one nose. Yeah. Yeah.
Were you able to make the design you had in mind for your case?	I do like the concept. I do think that now afterwards when I'm thinking more about it, I'm getting new research insights into how I could have used it. For example, I could have looked more at the cards and translated that into the sliders. Because now I

	see that there is not really a logical connection between the mouth card I picked and where I put the slider.
Were there enough options available? *If not, what were you missing?*	Yes, I think for now it does. I did have the ability to pick out everything I needed to create a robot. And I just really look forward to seeing what would come out. So it already made me very excited to see like, Okay, what have I created with the design tool?
Did you make use of the information and examples on the cards?	Yeah, I really also was looking for maybe having some points of like, where they are the same as the text was. So maybe searching for something that said, like cyborg, or something that said, realistic? So I was really looking into like what the cards say because I think everyone has a different perception of what they find realistic, or what they find human-like. So I really like to have the information on it. And especially the photos on the back. So you already get a clear view of what actually would look like in real life.
Was the concept of the expression sliders clear? Could this explanation be improved?	Yes, the concept was clear. Especially the text at the top helped me understand it.
What do you think of the design of the board?	I do think it's nicely structured. I also like the fact that you have two different boards, because that separates them from each other. So you don't have the feeling that it's one big assignment. And I do like the explanation at the bottom, because it makes it what you could do, and how to use the board.
Do you feel confident you can make a good design with this tool without requiring a lot of research?	Yeah, I think it gives enough explanation on the cards. So I will be confident that if I use the cards and really stick to what they are saying that I could create a robot that is actually fitted to maybe a project or scenario.
Are there any things you want to see	I really like it. Yeah, I think it's really really fun to see how this all came together

improved/ final remarks?	

Appendix E: Consent form: Interview The Robot Facebook

Please tick the appropriate boxes

	Yes	No
Taking part in the study		
I have read and understood the study information dated 10/10/2022, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves answering questions in an interview based style. The audio of the interview will be recorded. Later relevant parts of the audio recording will be transcribed as text and the recording will get destroyed.	○	○
Use of the information in the study		
I understand that the information I provide will be used for getting in depth information to help setting up relevant requirements and as inspiration for ideation. My answers may, anonymously, be used in reports belonging to this study.	○	○
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	○	○

Signatures

_____ _____ _____

Name of participant Signature Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name	Signature	Date

Study contact details for any further information: Mats van Braam, m.vanbraam@student.utwente.nl

Appendix F: Information brochure Interview The Robot Facebook

Research leader:
Name: Mats van Braam
Email: m.vanbraam@student.utwente.nl

Project supervisor:
Name: Edwin Dertien
Email: e.dertien@utwente.nl

10/10/2022

General information

The purpose of this interview is to gain knowledge on the topic of database design tools. This information is used to help support the ideation phase of The Robot Facebook project in which later such a new tool is developed. Information is obtained by means of interview questions. Questions on the current use of such tools and what is important within these tools are asked. This interview will happen in a semi-structured form.

Additional information

- Participants are able to decide to stop the interview at any time, not disclose information or decide to withdraw from the study, up to 24 hours after the interview took place. This will have no adverse effects on the participants.
- Data is used anonymously and no data will be used for purposes other than this research or shared with third parties.
- Participation in this interview is voluntary, and as such participants will receive no remuneration apart from the team's gratitude.
- There's always the possibility of new discoveries during the interview not directly pertaining to the intended research. If such a situation occurs, the participant will be asked for consent as to whether the information can be used. Consent will be acknowledged in terms of a signature from the participant.

Contact Information for Questions about Your Rights as a Research Participant
If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee of the Faculty of Electrical Engineering, Mathematics and Computer Science.
ethicscommittee-cis@utwente.nl

Appendix G: Consent form: The Robot Facebook - User test

Please tick the appropriate boxes

	Yes	No
Taking part in the study		
I have read and understood the study information dated 18/01/2023, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves being observed while interacting with the tool and afterwards answering questions in an interview. The audio of the interview will be recorded. Later relevant parts of the audio recording will be transcribed as text and the recording will get destroyed. As long as the data needs to be stored, it will get stored on the researcher's computer. Other people will not have access to these files.	○	○
Use of the information in the study		
I understand that the information I provide will be used for the evaluation of the product and possible future improvements. My answers may, anonymously, be used in the reports belonging to this study.	○	○
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	○	○

Signatures

_____	_____	_____
Name of participant	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name	Signature	Date

Study contact details for any further information: Mats van Braam, m.vanbraam@student.utwente.nl

Or the supervisor: Edwin Dertien, e.dertien@utwente.nl

Appendix H: Information brochure: User test The Robot Facebook

Research leader:
Name: Mats van Braam
Email: m.vanbraam@student.utwente.nl

Project supervisor:
Name: Edwin Dertien
Email: e.dertien@utwente.nl

18/01/2023

General information

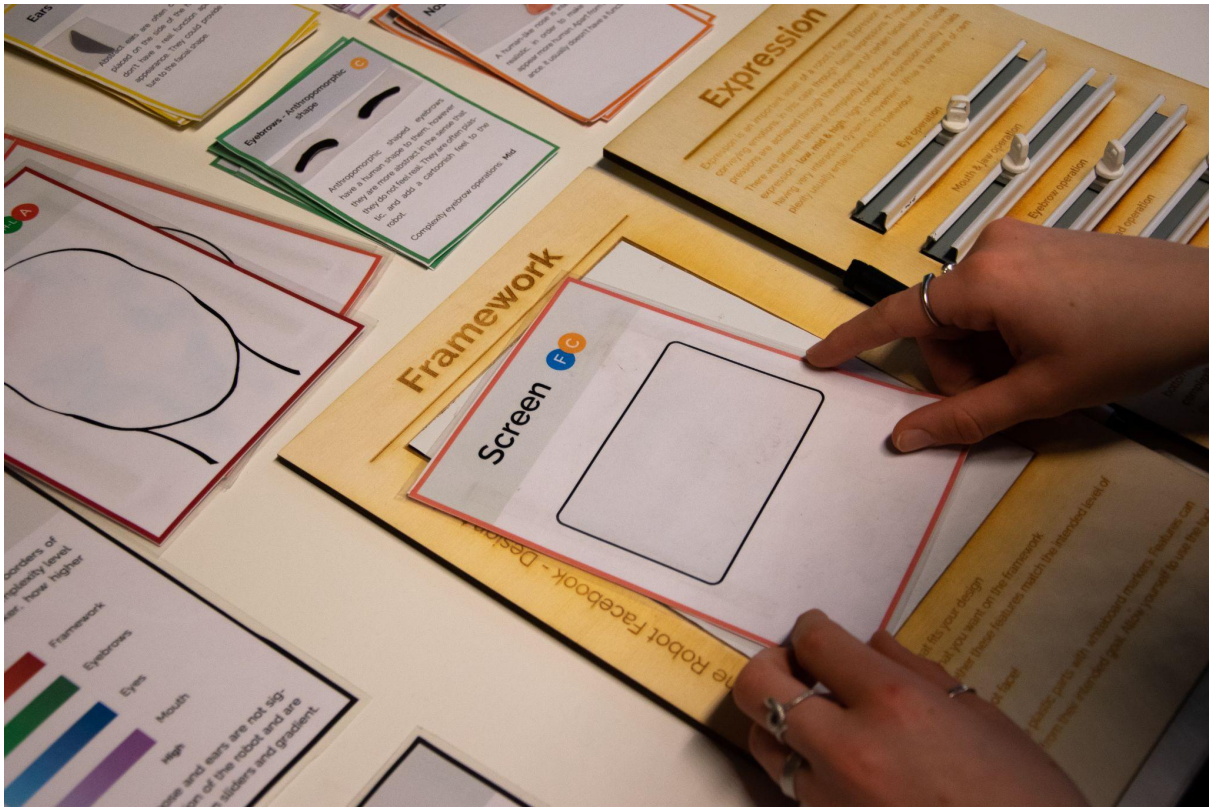
The robot facebook is a database of around 100 robot faces. In addition to this database, a design tool has been developed. This tool assists the designer in the process of designing a new robot face. The purpose of this user test is to evaluate the designed tool with relevant users. Information is obtained during this user test by means of observing the interaction with the tool, and by participating in an interview afterwards. Beforehand a short explanation of the actual product is given. Then an imaginary scenario is provided in which some requirements of a new robot face design are stated. Then the actual interaction will take place, keeping those requirements in mind. After the interaction is finished, an interview is held. The goal of this user test is to see whether possible future improvements can be made.

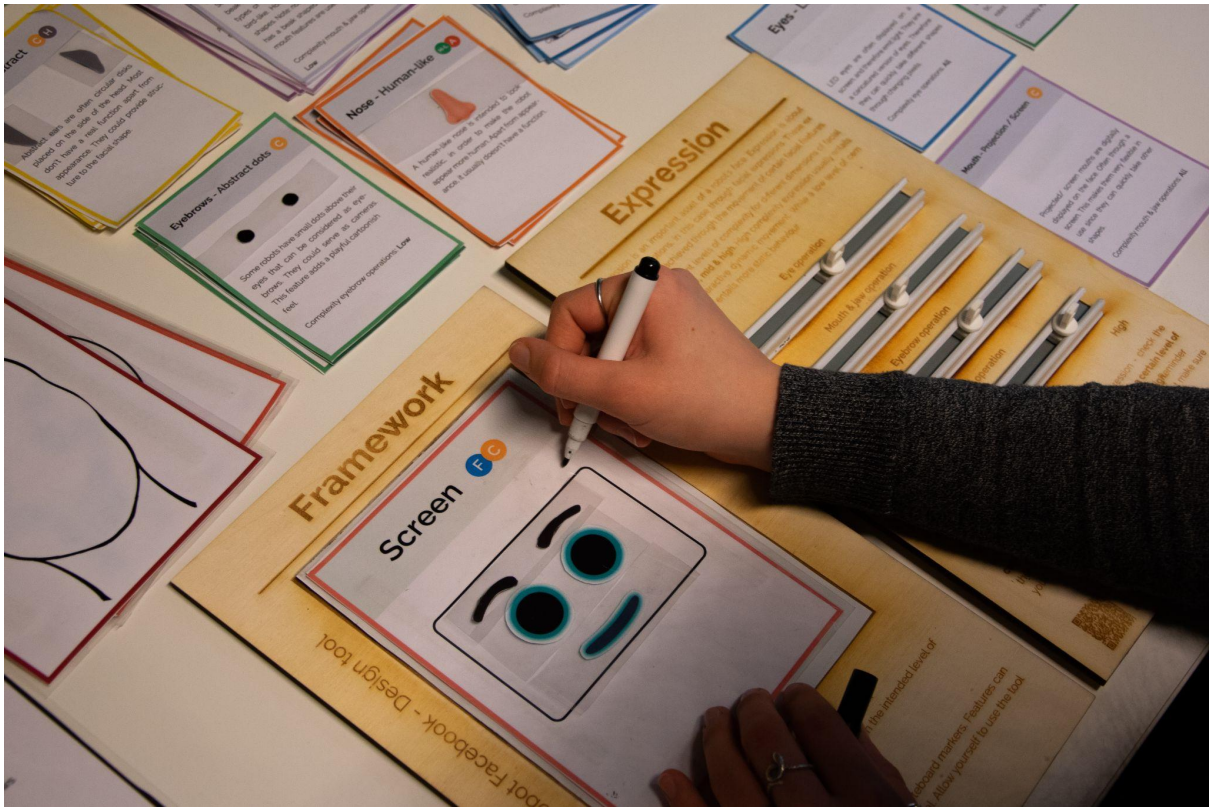
Additional information

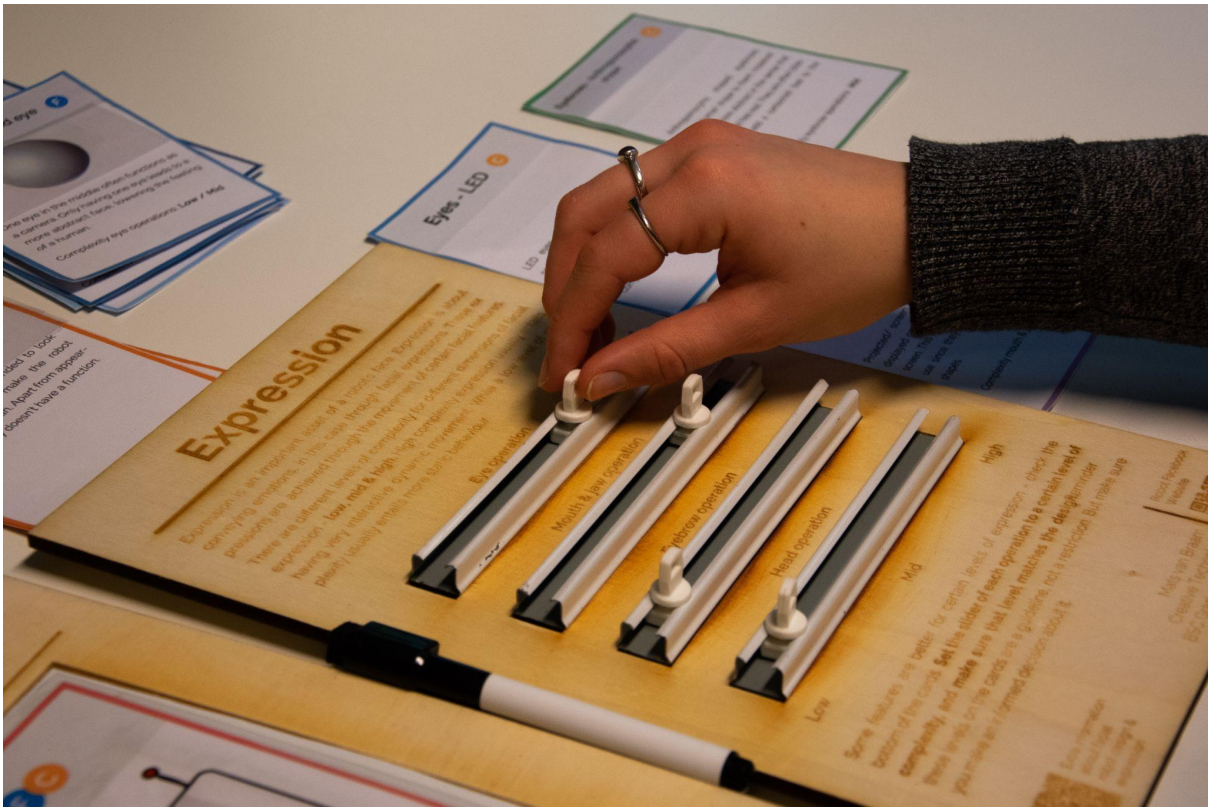
- Participants are able to decide to stop the interview at any time, not disclose information or decide to withdraw from the study, up to 24 hours after the interview took place. This will have no adverse effects on the participants.
- Data is used anonymously and no data will be used for purposes other than this research or shared with third parties.
- Participation in this interview is voluntary, and as such participants will receive no remuneration apart from the team's gratitude.

Contact Information for Questions about Your Rights as a Research Participant
If you have questions about your rights as a research participant or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee of the Faculty of Electrical Engineering, Mathematics and Computer Science.
ethicscommittee-cis@utwente.nl

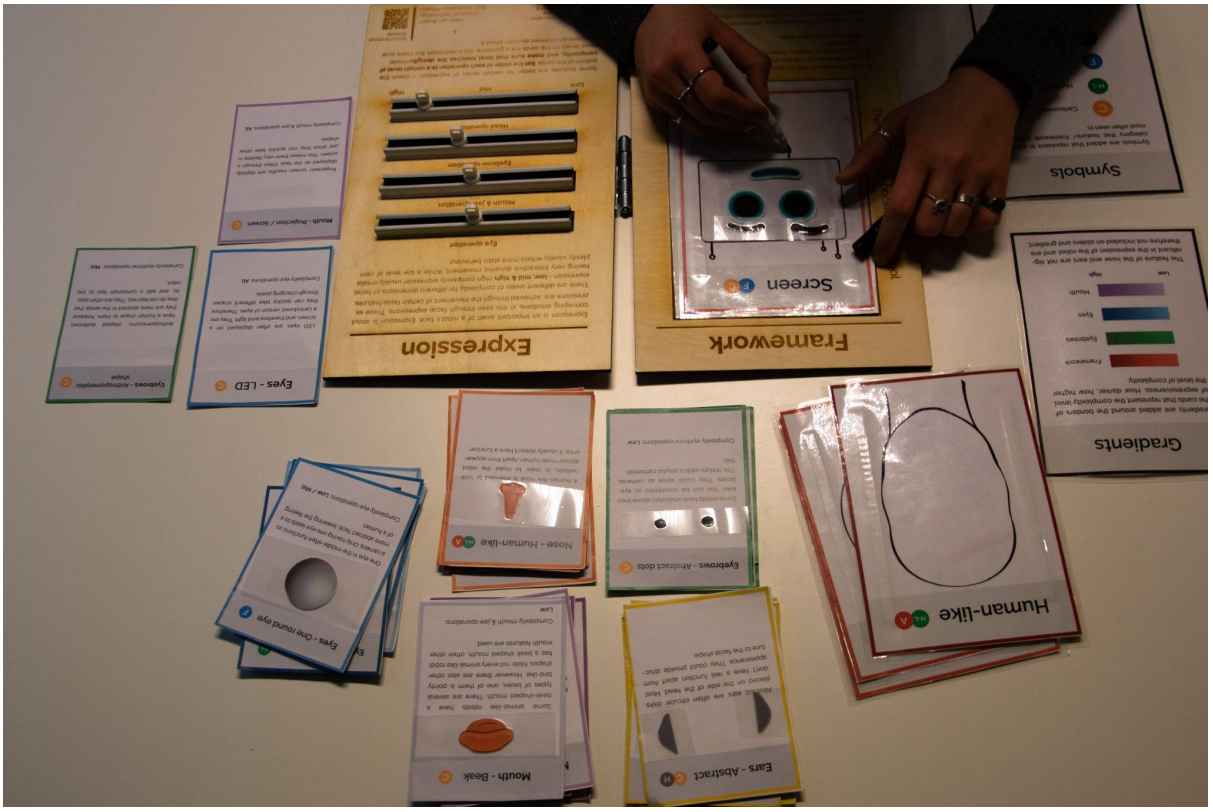
Appendix I: Additional pictures of prototype






Expression
Eyes - LED
Mouth & jaw operation
Eyebrow operation
Head operation
High
Mid
Low


Symbols
Symbols are added that represent in which category that feature/ framework can be most often seen in.
C Cartoonish
H-L Human-like
F Function defines form
H Helmets
A Anthropomorphic human
Framework
Screen
Human-like
Nose - Human-like
Eyebrows - Abstract dots
Eyes - One round eye
Head operation
High
Mid
Low


Expression
Framework
Screen
Symbols
Gradients
Human-like
Ears - Abstract
Mouth - Beak
Nose - Human-like
Eyebrows - Abstract dots
Eyes - One round eye
Eyes - LED
Mouth - Projector / Screen


shaped eyebrows
shape to them, however
more abstract in the sense that
do not feel real. They are often plas-
and add a cartoonish feel to the
lexity eyebrow operations: Mid