Bonding and the Artificial Womb: Creating an experience through meaningful interactions

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Abstract

This report showcases the research and design process for a master project on bonding with a child in an artificial womb.

Preliminary birth is the number one cause of death for infants, yearly resulting in 15 million deaths worldwide [1]. Even if a premature baby survives, they'll have to live the rest of their lives with the consequences of an early birth. In this early stage, the body of the child is not yet ready for life outside of the womb. For example light is still damaging for the underdeveloped eyes, and oxygen is still toxic for the underdeveloped lungs [2].

The artificial womb can solve these problems, but new questions emerge as a result; What will be the role of the parents in this new situation with a child in the artificial womb?

We designed an immersive experience that gives parents tactile, audible, and visual feedback from their child. This will result in co-regulation and thus strengthening the bond between parent and child [3]. We designed this immersive experience that can be used in the home as well as in the hospital setting. Used methods in this process include: Focus groups sessions, interviews, and user tests.

Read along to gain a deeper understanding about this process, co-regulation, bonding, fetal development, movement simulation and partnerhood. Resulting in the final design, the immersive experience.

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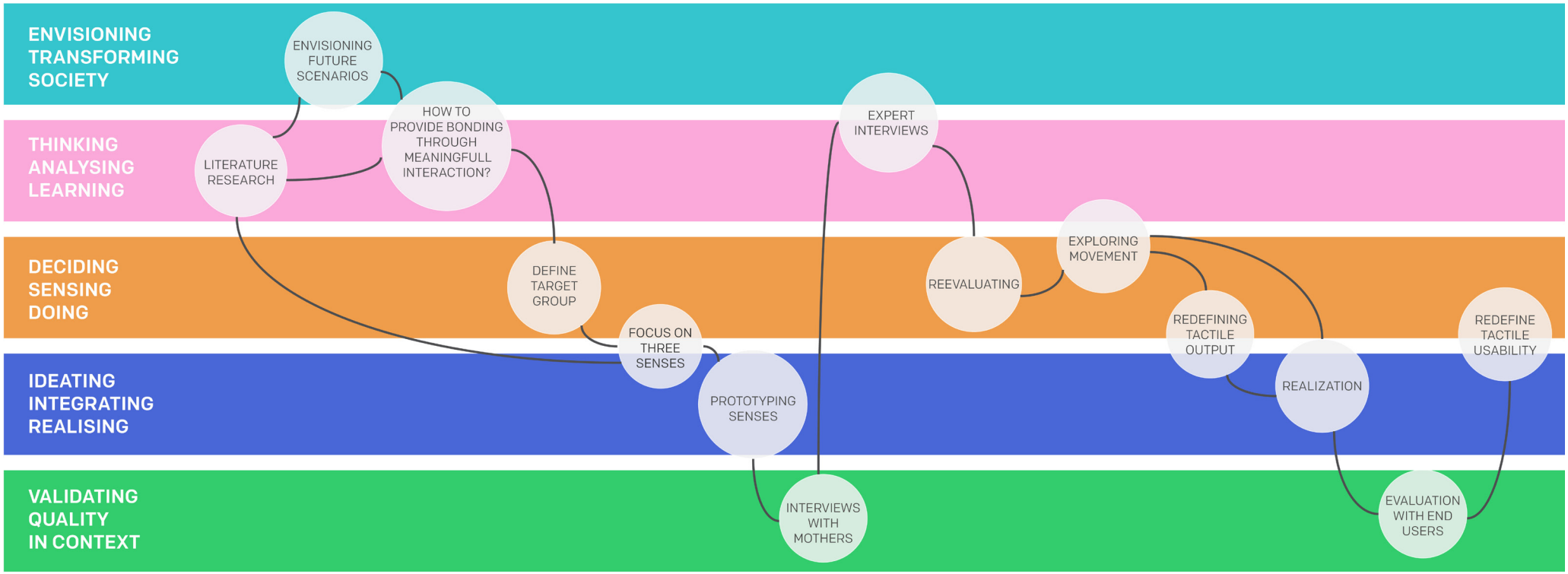
Design Process Summary

We are of the mind that keeping track of your design process is important to later reflect upon it. Using the reflective transformative design process framework [4] we visualized our process and the key decisions within it.



Introduction & Problem Statement

It gets louder with every scream. Suddenly, a touch and the first light rays on the skin, and a chilling breeze of air. It hurts. It hurts so much you want to scream, but you cannot. It is getting colder and you cannot run away. Then there is darkness and silence… again.

A baby was born, but too early. Oxygen is dangerous, light can hurt and the senses are not fully developed yet. Anything in our daily environment is harmful and can kill. Immediately after birth the child got transferred to a special unit and the only place it can survive without pain: The artificial womb. So the principle is simple: keep the child in an artificial womb until it is developed enough to be born for a second time, but then for good.

Preliminary birth is the number one cause of death for infants, yearly resulting in 15 million deaths worldwide [1]. Even if a premature baby survives, they'll have to live the rest of their lives with the consequences of an early birth. In this early stage, light is still damaging for the underdeveloped eyes, and oxygen is still toxic for the underdeveloped lungs [2]. The artificial womb can solve these problems, but new questions emerge as a result; What will be the role of the parents in this new situation with a child in the artificial womb?.

The most important aspect of the technology in the artificial womb is the biobag. This biobag has already been tested on lambs [5]. A biobag is a closed environment that mimics the uterine environment in order to sustain preterm fetuses for up to four weeks.

The new artificial womb technology could thus save the lives of preterm babies, supporting fetal organs further develop until they reach maturity. In the same way as it does for the lambs. However, this new technology could have negative side effects; During the development of the preterm babies behavioural problems could emerge later in life. [6] These new problems are due to expected disrupted parent-infant bonding, in other words: The bonding process.

In this scenario the parents and the child would be separated for a certain amount of time before the baby would get transferred to an incubator in the NICU. This period in the artificial womb seems short when looking at it from the outside and could lead to underestimating the importance of the interactions between parents and the baby [6].

The newborn is in an in-between stage: born and unborn at the same time. This context creates many challenges for various disciplines and requires new expertise and professions to make this journey happen. In this context the design profession is facing a unique challenges for all involved stakeholders, with one outshining any other: How to bond with a child while it is in the artificial womb?

Throughout the process we have developed the design challenge from this starting point and formalized the final challenge as follows:

Design an artifact that provides conscious bonding between baby in the AW and parents by creating an experience through meaningful interactions.

Theoretical Background Part 1

What is bonding?

For this report we use the definition for bonding, based on the work of Kommers [3]. The origins for this are found in the disciplines of psychologists and neuropsychologists:

Bonding: the process of co-regulation.
Either consciously or unconsciously (mainly the latter) helping other individuals regulate. Since regulation is a synonym for homeostasis (maintaining a stable internal environment by physiological processes), bonding in this thesis means to help another individual maintain homeostasis.

The quantity of co-regulation does not only reflect the strength of bonding between organisms, but as well the quality: timing, sensitivity, reliability. A takeaway for this design challenge is that both organisms involved in this bonding process are able to read the internal state of the other. While the baby is still within the womb of the biological mother the unconscious act of bonding is dominating.

An unconscious act of bonding is an “internally generated neurophysiologic act, enabled by the expression of physical parameters”, such as heart rate, temperature, scent, voice, facial expressions, et cetera, which are called cues. The sensitivity to such cues is a complex topic, which would require a deeper analysis of the evolutionary background and will be approximated during this project.

Further, the lack of knowledge about cues in the context of this project indicates that appropriate research methods can be found within the domain of “Research through Design“.

Unconscious and conscious cues

The design challenge needs to develop based on the core assumption that our design requires mostly conscious bonding since the communication between the two organisms is heavily constrained, due to the fact that the baby is physically isolated. This assumption leads to the conclusion that the exchange of cues between the two main stakeholders (parents and baby) are achieved through additional aid and is defining the broader design space available for this project. The decision to mainly look for digital aid is based on the direction of the study and the individual learning goals of the group members.

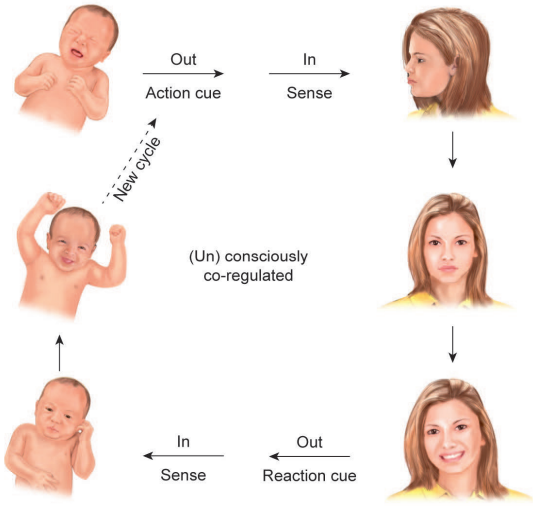


Figure 1. *Bonding process envisioned by a co-regulation cycle(Kommers et al. 8) Bonding is enabled by the continuous expression of innumerable cues, such as scent, heartbeat, vocalizations or changes in facial expression (top left). Cues are then perceived (top right), which leads to the co-regulation of the internal environment of the receiving organism (middle right), resulting in reaction cues to be expressed (bottom right), to be perceived (bottom left) and to be co-regulated by (middle left). This cycle is virtually endless.*

The neocortex is interesting for this project to read such cues, because it is responsible to consciously read actions, gestures and facial expressions [7]. This information can be then used to perceive and interpret the mental state and emotions of others with the possibility to determine the thoughts and feelings of the other. Behaviours seem to serve as a valuable source for cues, but to quantify the behaviour of a preterm infant is a challenge on its own.

Even more when this infant is physically isolated and stored in a water tank only accessible for professional caretakers. This constraint will lead to a focus on the parents as the main stakeholders during this project.

First Iteration - Ideation & Conceptualisation

The literature research was not as fruitful as expected, because there is no knowledge for our project's specific context - bonding with an infant who is already born, but isn't directly accessible by the parent(s) - available. We decided to move on to the ideation phase, but keep the literature research as an ongoing activity during this time in order to collect the necessary information. From the insights we had already gathered we started creating a work space where we could hang different types of informational and inspirational material.

One of these insights was concerning the ways of communicating cues from and to the neonate inside the artificial womb. We thus focussed on the different ways of communicating between parent(s) and child, and started to brainstorm on different ways of visualizing this. Because we lacked inspiration at this point, we created a moodboard in the form of a wall. This wall was used during our brainstorm sessions to inspire, stimulate and guide us (figure 2).

We picked different parts of the wall to focus on and continued brainstorming, both individually and together, in the form of sketching and idea collecting onto other moodboards (figure 3,4 and 5).

Figure 2. (right) *A moodboard that is comprised of numerous sources and backgrounds. It was used to stimulate and guide us in our ideation.*

Another technique that we implemented in our ideation phase was the MoSCoW method (figure 6) [8]. This is a method commonly used in product development to determine what a prototype (or concept) must, should, could and will not have. We used this method in order to prioritize the requirements of our concept and direct our ideation phase towards a clear and achievable goal.

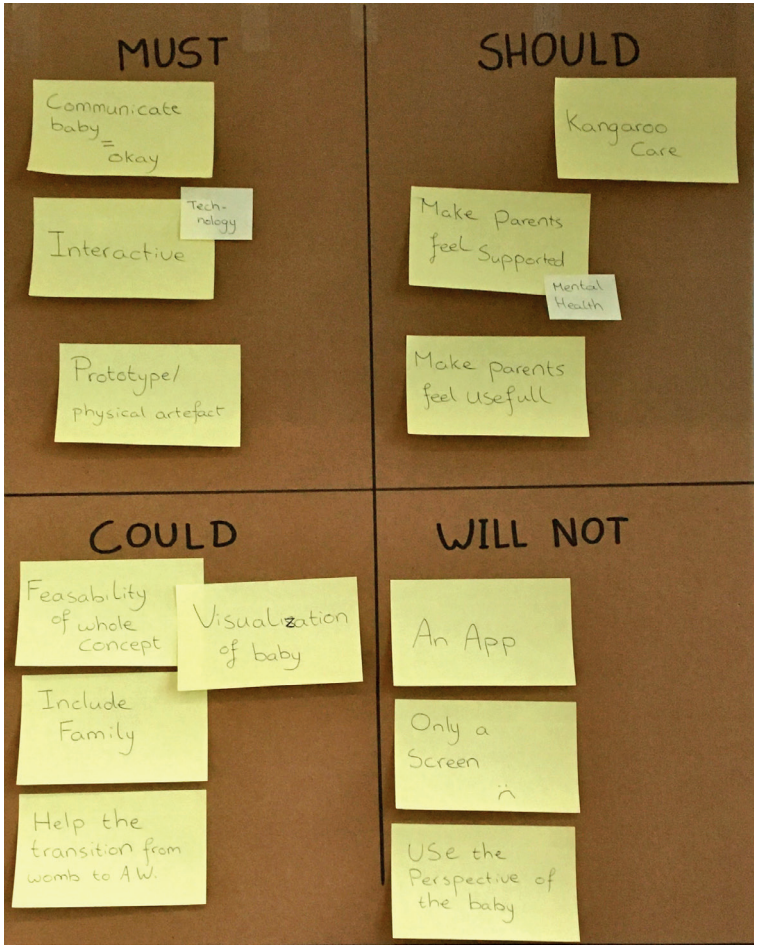
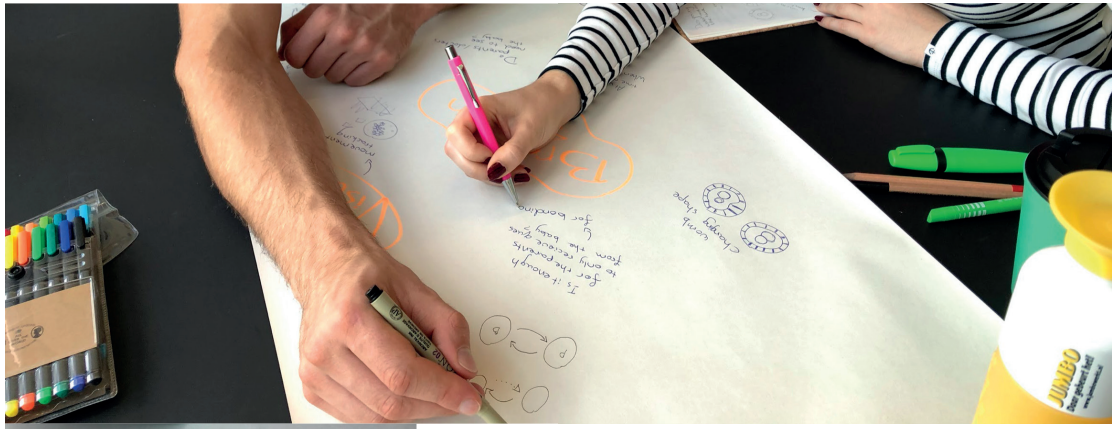


Figure 6. (left) *The MoSCoW analysis we made after our first ideation. It helped us to prioritize the requirements of our concept and formulate a clear and achievable goal.*



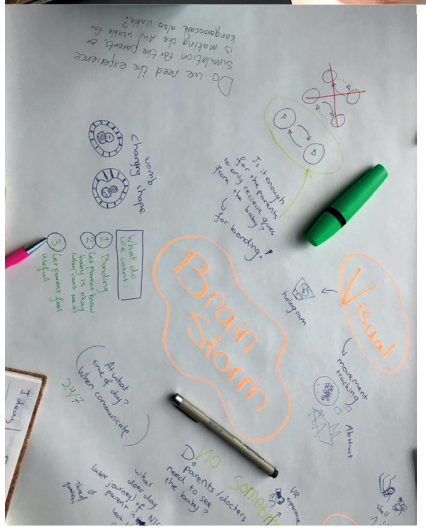


Figure 3. (top) *One of the brainstorms we did, writing and visualising our ideas on a big piece of paper at the same time to start the conversation.*

Figure 4. (left) *The result of the brainstorm. A collection of ideas that were investigated further.*

Figure 5. (right) *A visualisation of how we envisioned our concept after the first ideation phase.*

Based on our research we created a timeline overview of the development for a neonate, including a timeline of a pregnancy as it would normally occur and stakeholder involvement in the different periods of pregnancy and development (appendix A). We then further ideated with the help of the data that is visualised in this timeline. An app was also created to better and more clearly showcase the data, and to make the timeline more accessible.

From the data in the timeline we started to explore the different stakeholders and visualised this. We came to the conclusion that all of the stakeholders are connected with one another, even though the stakeholders are not always simultaneously present during certain phases of the development. In some way they all need or interact with each other (figure 7).

Our first design challenge was then defined: How to design an interaction for the optimal bonding experience in the artificial womb. In order to help us answer this question we also needed to define a target group.

The target group we defined are opposite-sex couples that live together and are the biological parents of a premature baby inhabiting the artificial womb. The new parents are between the ages of 30 to 45. This is based on data from CBS, and indicates the average age to have a first child until the average start of the menopause [9]. We recognize families exists in all different shapes and sizes, which therefore is exactly the reason why it was important for us to define a clear target group to specify our design to. However, we are not excluding families who fall out of this target group to use the designed product.

Because the pregnancy and NICU experiences are so personal we have to take into account many different user experiences. After speaking to parents (to be) who are experiencing or have experienced pregnancy and this transitioning phase into parenthood, we started to get a clearer image of the different types of users we are designing for.

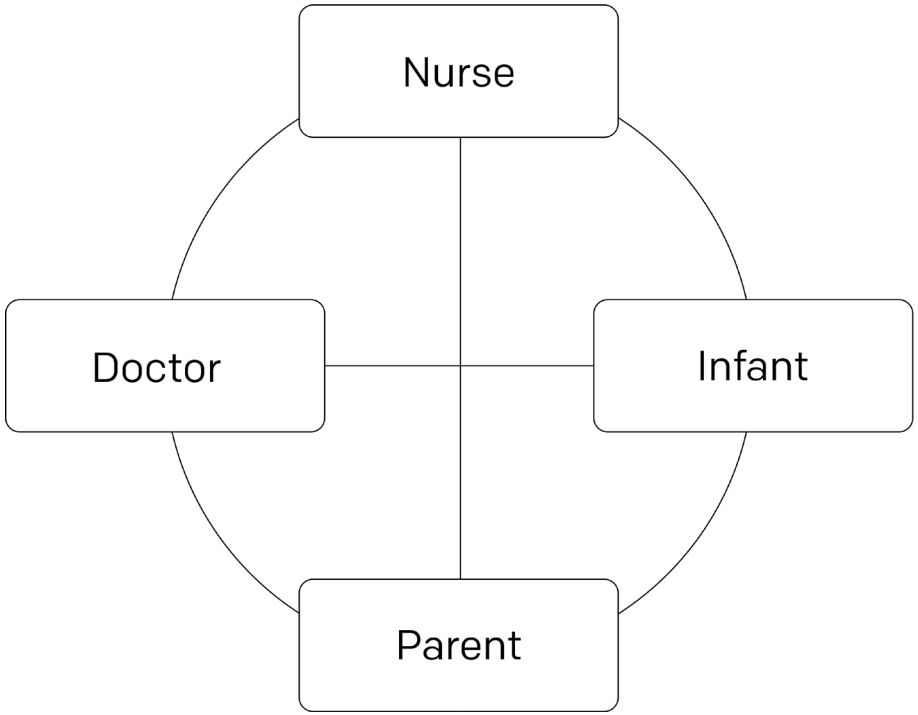
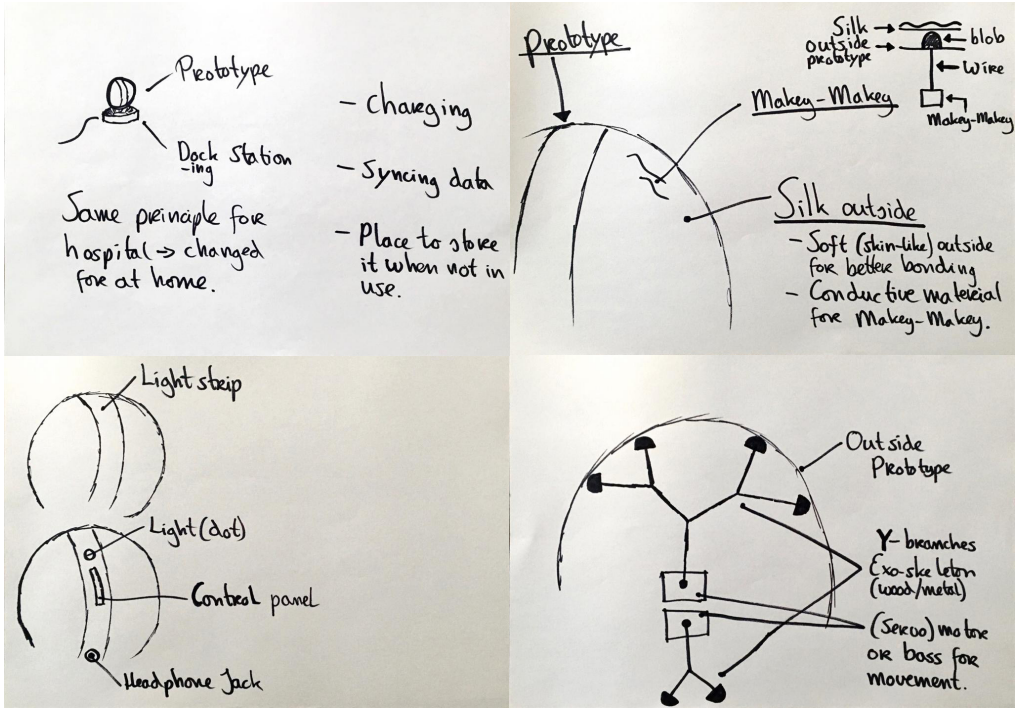


Figure 7. *A visualisation of how we see the different interactions between all stakeholders. This is a heavily simplified version, since their are numerous doctors and specialists involved.*

While sketching we thus focussed on the context of our design. Initially we were not given a user scenario (e.i.: Where would our future prototype be used, and who would be using it), thus we imagined two scenarios ourselves. The scenarios are based on the target group study we did previously.

The first scenario (figure 8) is that of two parents inside a hospital. They visit their baby in the artificial womb and can use the prototype in a separate space allocated to them to create a moment of being together. The second scenario we sketched (figure 9) was that of two parents at home, using the prototype to connect with their child over a distance, creating the same effect.

Our first attempt at finding an answer to our design challenge began at a second phase of brainstorming. These brainstorming sessions included sketching and group meetings to discuss what we had ideated. We selected different ideas in these group meetings in order to further converge on a final prototype. Some sketches of this brainstorming phase can be seen below (figure 10).



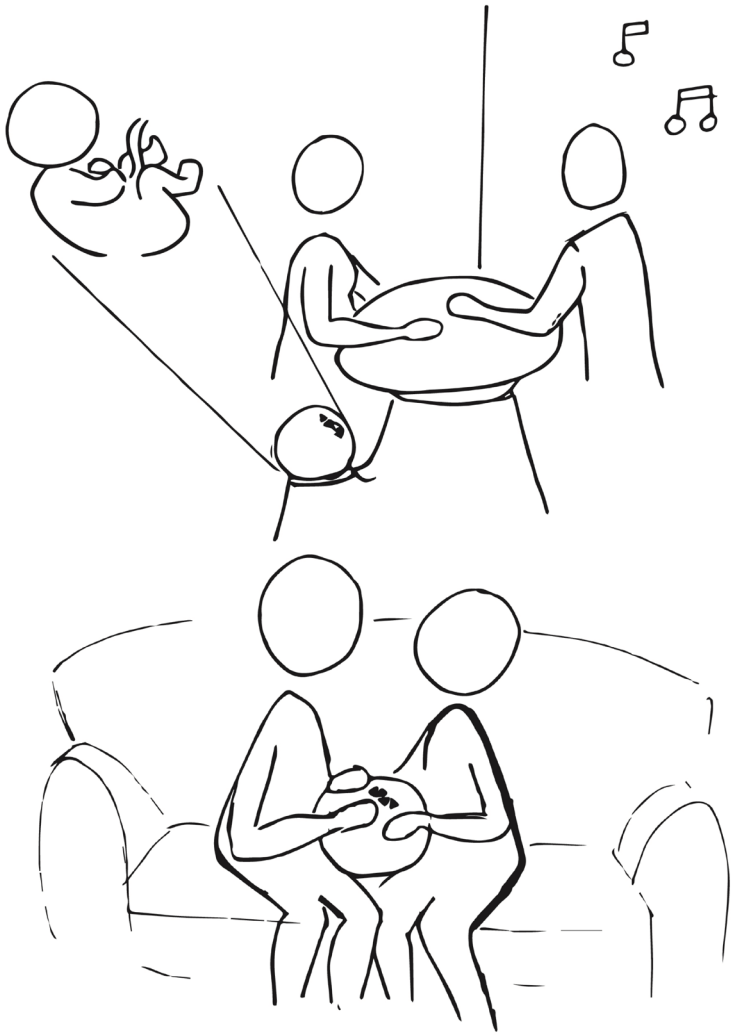


Figure 8. (top) *The first scenario of two parents inside the hospital interacting with the artifact in a designated room.*

Figure 9. (bottom) *The second scenario of two parents at home interacting with the artifact to communicate with their child inside the hospital.*

FIgure 10. (left) *Some sketches of this brainstorm session. These ideas were further investigated.*

We've selected these sketches as they were the first steps towards our final prototype. We thought of a communication device that would transfer the live data of a baby in the artificial womb to the parents and back. This device would transfer visual, tactile and audible data and could be taken home with the parents from the hospital. After determining a general shape and design, we started by creating a very simple paper prototype of how fabric patches could be spread over a sphere in order to visualise the shape of our first prototype (figure 11).

We translated this concept into a real prototype through the use of different materials and our moodboard which we used for inspiration for the design.

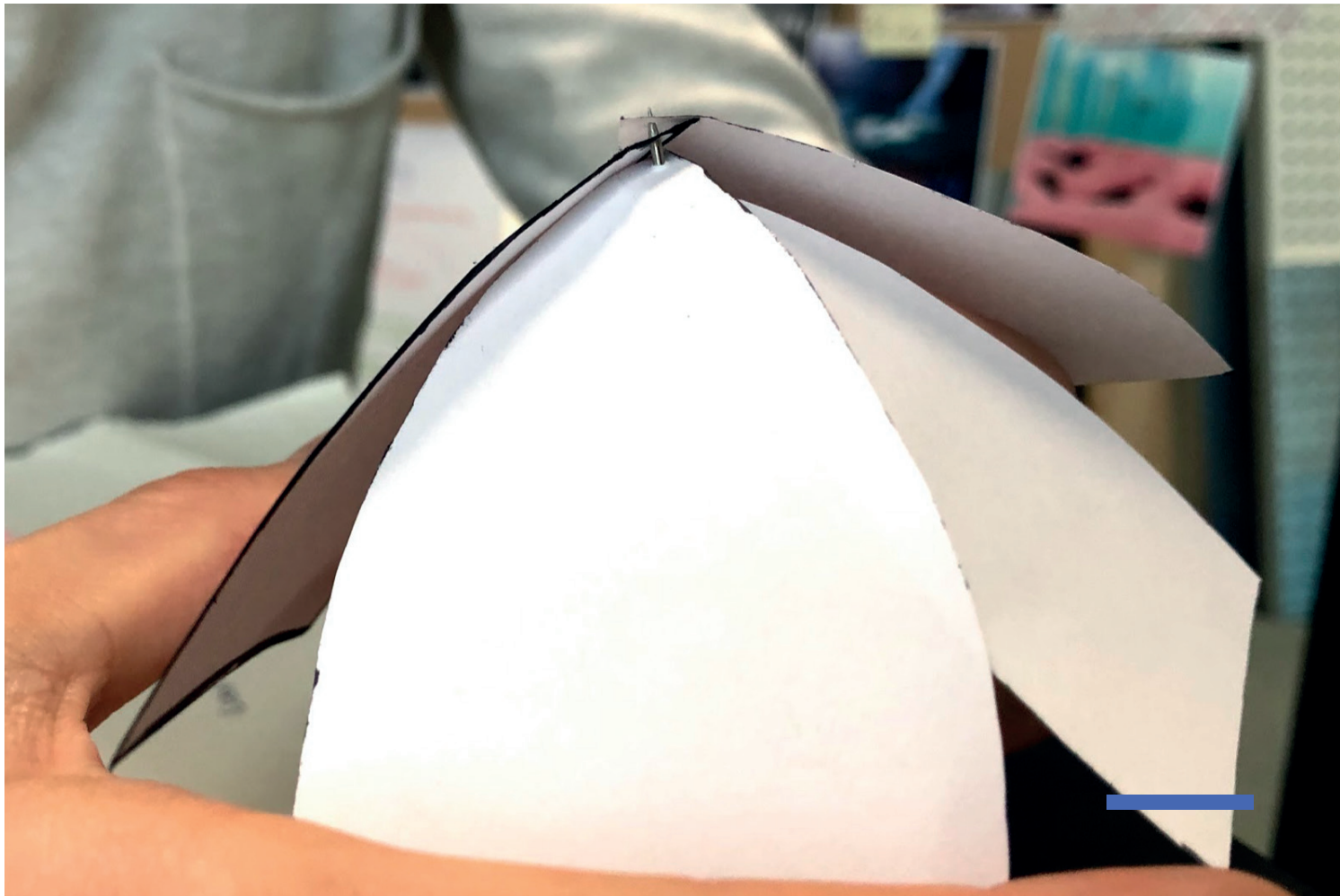


Figure 11. *A simple paper prototype to explore the possibilities of stretching fabric over a dome. It was inspired by an umbrella.*

Theoretical Background Part 2

Pregnancy as a transition

During the previous Ideation phase literature was still being reviewed. We reflected on the situation and concluded that too much time has already been spent on this phase and even more time would be required to be able to base well informed decisions on the findings when looking from a biochemical perspective as done in the work from Kommers. Nevertheless there was one benefit of the review which we have not taken into account yet: understanding the various contexts we are moving in (figure 12).

This is a design project which requires us to make assumptions and reason decisions for a non-existing user group based on quasi-similar scenarios, very limited research, fundamental lack of specific knowledge of the bonding process in the artificial womb context etc. This is why we saw it as beneficial to play with the perspectives and understand the various context-layers this process is placed in, which proved to lead to more fruitful insights.

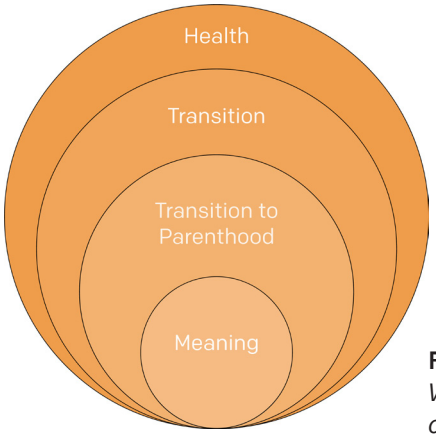


Figure 12.
Visual representation of the context.

Health

The context in which this project is placed is defined by the health squad as follows: […]We focus on applying state-of-the-art technology and design to the healthcare context. Solutions that we design focus on providing the right care, rather than the best care. […] [10].

Transition

The literature review on transition [11] concludes that "transition" is a commonly used concept in health literature, but the meaning of this word depends on the context in which it is used. It is frequently used to describe "a process of change in life's developmental stages, or alterations in health and social circumstances, rather than people's responses of change".

The working definition developed by [12] is highlighting that a transition is a process in which people are pushed to redefine their sense of self and redevelop self-agency in response to such disruptive life events. Further, helpful to keep in mind is that "every transition begins with an ending" [13], meaning that the user is launched into this process in which the user is exposed to new experiences and situations while bonding with the child inside the artificial womb and that time as a variable will be required to cope with the new.

Conditions that influence transitions have been explored by [14] shown on the graphic below. This gives us a sense what conditions our design intention lays focus on and to better reflect on its goal. We are concerned specifically on the emotional and physical well-being of the parents. According to Schumacher & Meleis the emotional state make a transition successful, because "Feelings of distress are replaced with a sense of well-being and mastery of a change event". This insight means for our design should aid to provide such emotions while the user is undergoing the transition to have some measurement if the transition is successful or not. A sense of mastery involves the acquisition of information and means for us that we should introduce this aspect to keep the parents on track (figure 13) [15,16].

Transition to parenthood

"Themes involving loss of self or shifts in self-identity as a result of the uncertainty and turmoil that follow a crisis event or disruption emerged from several inquiries" [11].

We see pregnancy as a journey in which two people are going through a transition, which is altering their future in many ways. To take the responsibility to become a parent is a life determining choice and a challenge in itself, which is calling for action. To lose a baby can be a traumatising experience and the journey of the parents with their infant in an artificial womb has the same potential. Further, the consequences of a failed bonding phase with the infant could lead to deep consequences for the relationship with the child throughout life [6].

It is in the interest of the involved stakeholders to realize a healthy transition to parenthood despite the challenges of having an early birth. What this mindset takes into account is the higher goal of the parents of adopting the responsibility that is ahead of them and accompany them on their difficult journey to a desired future for everyone involved. Further, that they will experience changes in self-image, relationships with others and their partner [17,18]. All these aspects make the pregnancy a meaningful event for both partners.

Meaning

The previous thoughts can give us indicators when the design becomes meaningful for the parents when it supports:

- The overall transition to parenthood.
- The will to bond.

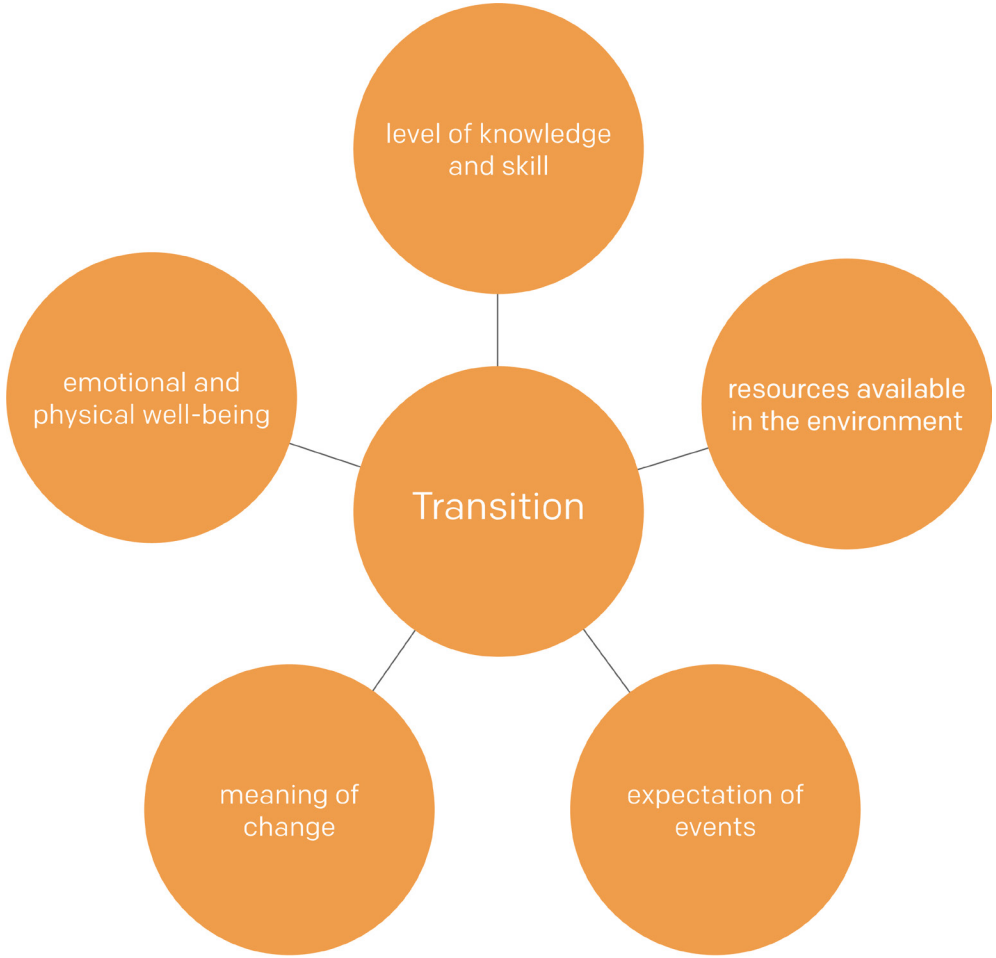


Figure 13. *Aspects of the transition.*

First Iteration - Realisation

After our first ideation and conceptualisation we created several experiential prototypes in order to physicalize our vision. In order to provide the full experience of interacting with a child in an artificial womb, we created three prototypes that tapped into three different senses: sight, hearing and touch. In the following sections we will elaborate on all three in more detail.

Sight

Since the eyes of the baby are not fully developed yet at 24-28 weeks, the artificial womb will not be able to be transparent and the eyes of the baby cannot receive any light, otherwise it can damage their eyes. This means that it will not be able to see your child directly, only via ultrasound/infrared images. Therefore, we created an abstract “live” visualisation of your child, in order to give an impression of what it would feel and look like to have a child in an artificial womb.

The prototype was created using Processing, of which the code can be found in appendix B. We use an array of 30.000 small cubes to mimic a ‘floating’ effect, and we use a png contour of a baby which determines the colour of the floating cubes. Once a cube reaches the inside of the contour, the colour changes to a lighter shade. Once it goes outside the contour again, the colour changes to a darker shade again. In this way there appears to be an object in the centre of the screen, but it basically consists of moving pixels passing in and out of the contour. Since the squares have a size of 4 pixels in height and width, passing in and out of the contour slightly moves the contour, creating a sense of movement, almost mimicking small real movements of a baby inside the womb.

Hearing

Having a child in the artificial womb can feel like it has been taken from you, causing a sense of distance between you and your child. In order to give the feeling that you are actually close to your child, we used a wireless headphone with sounds recorded inside an actual womb, where you can hear both the fluids flowing and the heartbeat of your child [19].

Touch

In order to give an even closer experience to your child, we also wanted to provide the feeling that you can actually touch and interact with your child inside the artificial womb. Since it will be impossible to actually touch your child skin to skin, we used some sort of haptic interface where the movements of the baby will be communicated through (figure 14).

Our initial idea was to create a full sphere, but during the realisation process we realised that it would be very difficult to produce a haptic sphere. Therefore we decided to focus on half a sphere, to still provide the experience, but making it more feasible for us to prototype. It consisted of half of a sphere made out of styrofoam with a stretchable fabric over it.

On the fabric laser cut triangles are glued to make it more visually appealing. On the inside of the sphere a 180 servo motor is attached with a small lever made out of styrodur to provide a kicking sensation just like in a real womb.

Figure 14. *Half a dome with a servo motor inside, that pushes through the fabric to mimic a kick of a baby. The MDF triangles are used to create a visually appealing look.*

First Iteration - Evaluation

The first opportunity we got to present our prototypes was the midterm Demo Day (figure 15). There we provided the full experience using all three prototypes at the same time. Here we got the opportunity to gather feedback on our concept from all the coaches and fellow students.

The feedback that we got the most was that the whole experience was really nice, however, no one could identify why. We assume this to be a result of a combination of senses, all working together to provide a multidimensional experience. We also noticed that the headphones with the sound play a big part in this, because it provides a ‘confined’ space where you can be alone with your senses, especially once you turn the volume up and all the background noise is removed.

We also received some points of improvement on our concept. The most important thing was that the haptic prototypes felt really artificial, both material wise and interaction wise. The sharp corners of the mdf triangles didn’t feel nice, and the movement of the servo was too consistent. And there was basically no interaction possible.

Therefore, for our next iteration we decided to focus on the haptic prototype, improving the experience by changing the materials, and providing an interaction with the artifact. Rather than programming consistency in movement, we wanted to replicate the real life experience, where an unborn child moves more inconsistent, and where it can respond to the input of the mother and father.

Figure 15. *The setup of the midterm demoday. All three prototypes were combined in one experience, just like the concept envisioned.*

Co-Creation

To best educate ourselves on the situation of the families in this future scenario and their needs, we reached out to people who stood closest to our target users as possible. Mothers, and mother to be. After looking at forums and reaching out to online communities of mothers with premature children, we also met up with a group of parents with pregnancies without implications who were interested in participating in a focus group session of the design progress (figure 16). To evaluate the current prototype, co-create together with them, and gain more insight into the pregnancy experience through a semi-structured interview and making a user journey (appendix C). We spoke to a total of five mothers and one woman currently pregnant with her first child, about bonding with the child during natural pregnancy, ways of communication, and we went in detail about the immersive experience of the prototype and its usability.

These sessions were audio-recorded and later transcribed. These transcripts were analyzed by doing a Thematic analysis [20]. This transcript and all upcoming ones have been translated to english. (See full transcription and analysis, including additional pictures of the session, in appendix D).

With the question “what do parents with a baby in an artificial womb need?” the main issues new parents potentially struggle with quickly became clear. Fear, nescience, and helplessness. These were interesting points that inspired us for our next iteration.
The main insights of the session, based on quotes by the participating mothers, can be summarized as:

- Re-confirmation of presence baby is one of the most connecting things during pregnancy: “The times that you feel your baby move is when you feel most connected with him or her. A moment of confirmation. Oh, yes my baby is still here, still with me.”

- The bonding effect influences more connections that just between mother and child: “I can imagine this can also be nice for the father to have this bonding experience! So it helps with the bonding for multiple relationships, not just mother and child!”

- The three senses together have the strongest effect: “All the senses definitely belongs together! Only the feeling would not have the same effect. Hearing the heartbeat and then feeling the movement is what makes it very real for me.”

- The movement of the touch prototype feels too artificial: “I must say that it [the touch prototype] is too on ritme, a real baby moves very randomly! They kick a few times, and then not for a while. But not this consistently. Sometimes harder sometimes softer. And not just at one spot they can kick everywhere. So you will need to work on your nuance.”

- Touch is a strong way of communication:“If I touched my belly my baby would follow my hand! So he definitely responded to me.”

- Shape causes confusion about translation of movements of the actual baby:
“is this the actual size? Because it is way smaller than the actual baby right? So that is different than how you would really experience it as a mom.”

Figure 16. *A picture taken during the co-evaluation session during the sharing of the needs of each individual.*

Second Iteration - Ideation & Conceptualisation

Expert Interviews

What techniques are experts currently using to help new parents with bonding issues? What is the role of a parent in the current situation of the NICU? These are some of the many questions that arose from reflecting on the first iteration. To find answers to these questions we conducted semi-structured interviews with a pregnancy coach and a NICU doctor-researcher. The pregnancy coach from Trescoaching, a mother of three, works with couples who encounter difficulties during pregnancy or after birth. Amongst which; bonding issues and dealing with an unhealthy newborn.

The NICU doctor-researcher from Maxima Medical Center, currently pregnant with her first child, is an expert about premature birth and knows the situation in the hospital (figure 17).

These interviews were audio-recorded and later transcribed. The transcript of the interview with the NICU doctor-researcher was analyzed by doing a Thematic analysis [20].

Our main insights from the interview with the pregnancy coach can be found on the next page.

Figure 17. *A picture taken during our visit at the Maxima Medisch Centrum.*

- The experience can be very metally challenging for the new parents: “There is such a fear involved! And that is really fear that is about life and death. Then it would be very nice if there is attention for it! For the person behind the pregnant. Not only the big belly, but that is also a human being! And a partner!”

- “It is such a big change in your life, sometimes during pregnancy there is something different than what you had expected and that disappointment or that guilt is heavy. It is important for parents to know that it is very normal if it is not love at first sight with their baby, if there are implications during pregnancy it is very normal! That connection just needs to grow.”

- Good mental health of the parents is important for bonding with their child: “There is no one exercise I can do with mothers to help them build that connection with their child. What I can do is comfort women and empower them. Then that connection will grow! I ask mothers, what do YOU need now? A healthy mothers is important for the connection with the child.”

- One on one contact is wanted: “Especially dad’s occasionally tell me that they feel all the attention is only on the mother. They miss the moment of one on one contact with their child.”

- We should give parents options (everyone is different and wants to interact with their child in different ways and at different times and places): “You should give parents as many possibilities as possible to connect with their child, it will differ per parent which ones they’ll use. But it is important the choice is there. Every parent is different and has different needs.”

Our main insights from the interview with the NICU doctor-researcher:

- Parents can sleep in a private room in the hospital when their child is in the NICU: “Here at the NICU we want the parents to be here as much as possible, and we want them to be seen as the primary caregivers. We provide family-centered care, so parents are always welcome to stay also during the night and sleep [in a private room] with their baby.”

- The experience is soothing and will potentially help parents cope with the stress at NICU: “The sound works soothing, even if I’m aware it’s not the sound of my own baby. Then you’re speaking about a different concept than bonding, even though it contributes to bonding surely. Stressful emotions from the parents can hinder the bonding process. So if the prototype makes parents more relaxed it indirectly helps the bonding process.”

For co-regulation the parents should get (live) data from their own baby: “When speaking about beneficially influencing the bonding process between parents and child in the artificial womb you’ll need to provide the parents with signals from the child itself. Even if it is not technically feasible yet, you can conceptually realise it. If this is done than you can refer to it as part of co-regulation.”

There is potential in this concept: “I believe it’ll work. If I can place my hand on something and feel my own child even if it’s away, and I’m aware it’s MY child. Yes that would be beautiful, I see potential in that concept.”

Less Artificial Movement

In order to convert the artificial experience into a more natural one, we went back to the drawing board to revise the mechanism entirely. In order to have 360 degrees reach inside the half sphere, we adjusted the arm from 1 rotation point to two, as you can see in figure 18. For this prototype we used cardboard as our medium, since it is quick and easy to work with.

It represents the human arm/leg, and it is able to reach every point on a spherical plane. Since the upper circle can rotate on the bottom plate, you also have a 360 degrees rotation horizontally. However, after further brainstorming we realised that it would be really difficult to realise this concept, since the top servo needs to be supported by the bottom servo, already putting a big load on the bottom servo motor. Therefore, we decided to skip one of the servo motors and go back to an arm with one segment. This would still provide a 360 degrees movement in the horizontal plane, and to provide a more natural feeling throughout. The exact configuration and parts of the final prototype can be found in the coming sections.

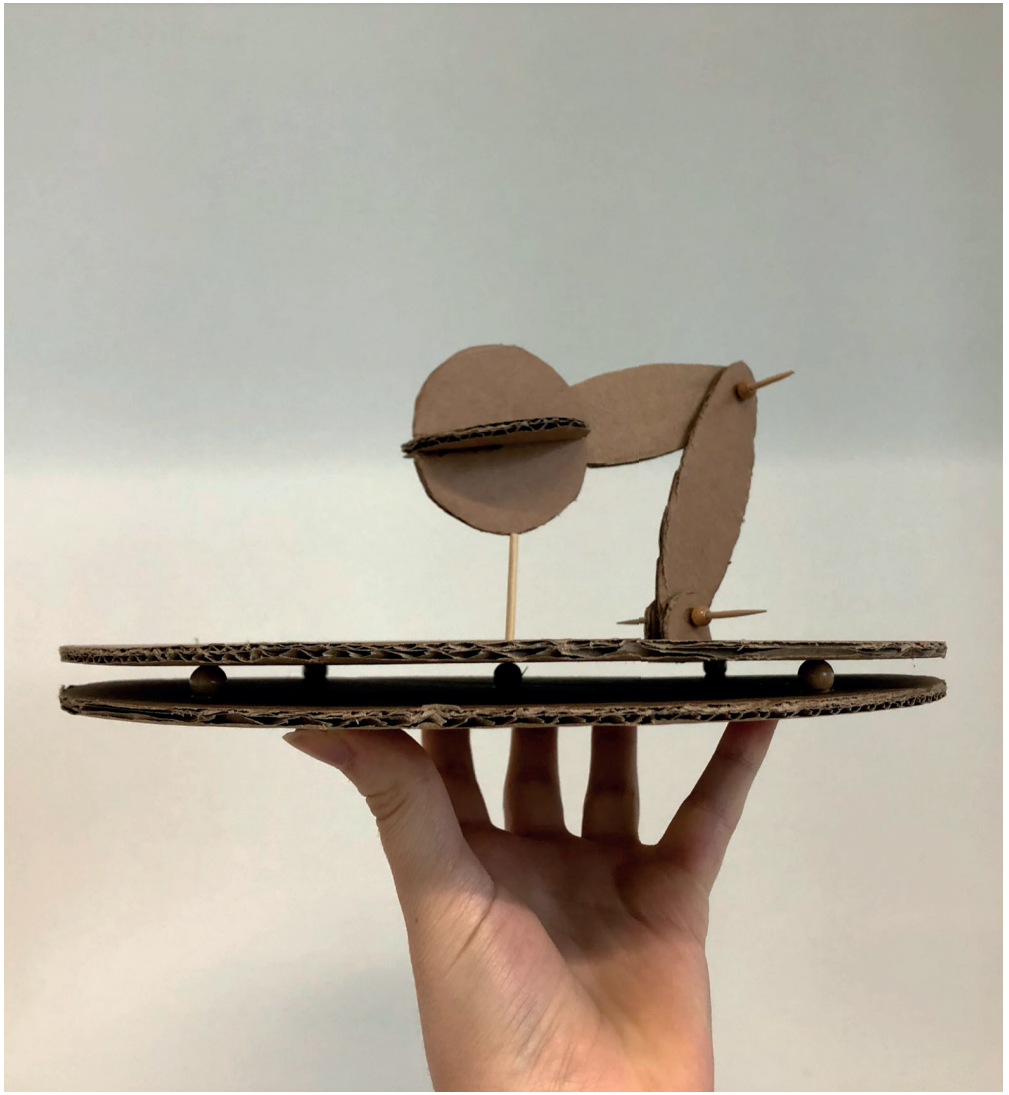


Figure 18. *A low-fidelity prototype using cardboard to communicate our ideas regarding the robot arm.*

Second Iteration - Realisation

After the first evaluation with our target group and the experts we went back to the drawing table to reshape and rethink our concept, and more specifically, our haptic prototype (figure 19). In the next section we will elaborate on the changes we made and the things we added based on the first evaluation.

Materials

One of the comments that we received multiple times is that the materials should be softer and more pleasant to the touch. We should avoid hard and sharp edges, and make it more 'friendly'. To support the whole structure, we used a big drainage pipe with a diameter of 30 cm that is commonly used in gardening. In order to keep that soft feel throughout the prototype, we stretches the spandex over the structure in such a way that it still has some stretch left, so that when you touch it still gives in a little bit.

We also substituted the laser cut triangles by vilt triangles, which is softer to the touch, but still are somewhat sturdy to support the interaction we are aiming for. What this actually means is explained in the next section.

Figure 20. (left) *A visualisation of the matrix of patches on the top of our prototype. the coloured patches are connected to the analog inputs, and the grey patches are all connected to the ground.*

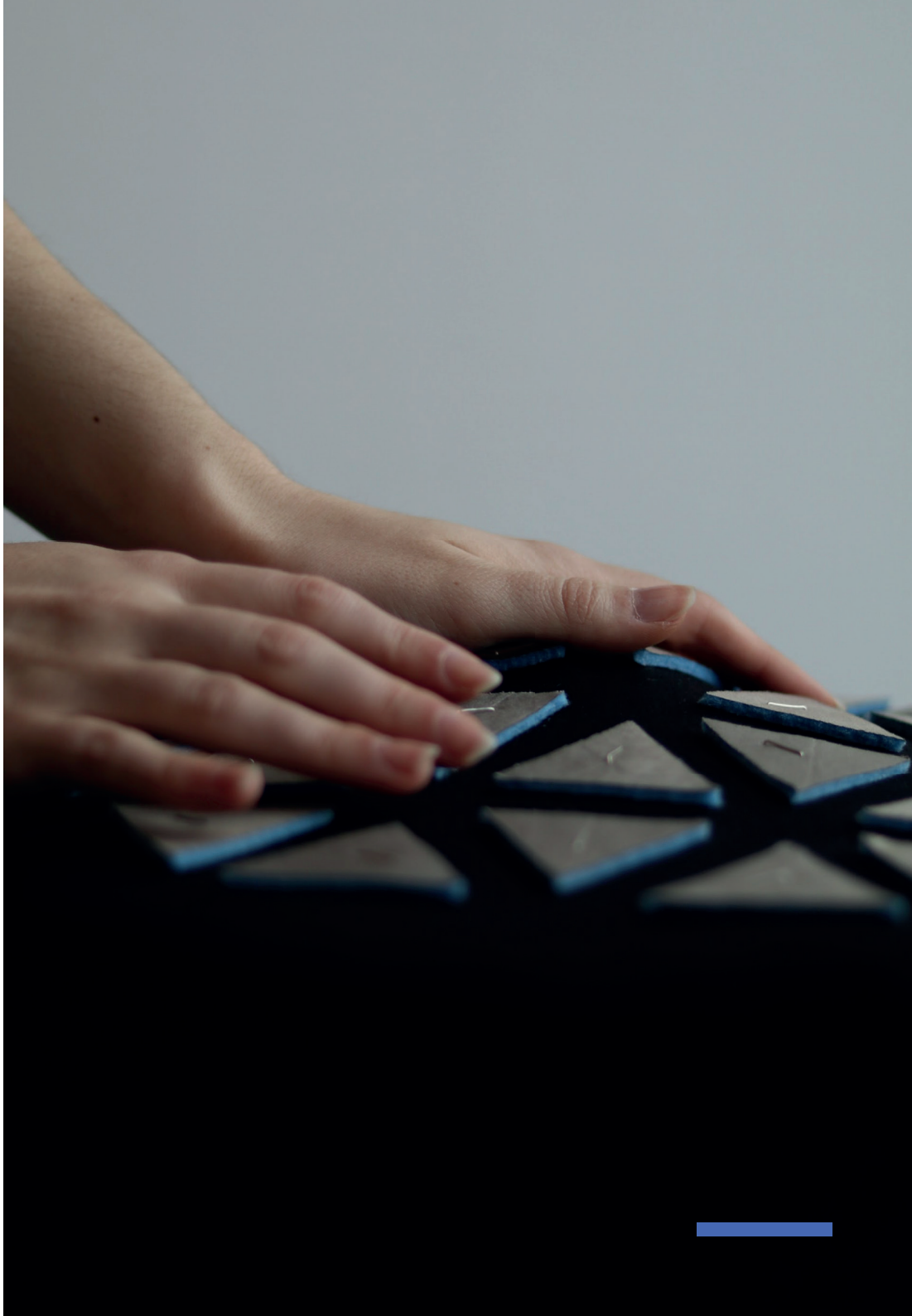


Figure 19. (right) *A picture of the prototype of iteration 2. In the coming sections we will elaborate on the different parts and functions.*

Interaction

First of all, we increased the prototype in size, so that it more resembles natural womb, where you can place both hands on. One of the major points of feedback we got was that the haptics should be less artificial. Therefore, we completely revisioned the interaction with the prototype.

While the first prototype didn't respond to any input, the second prototype only activates when input is received. We experimented with different sensors and which sensor would suit our concept. We experimented with Time of Flight sensors, pressure sensors, heat sensors, light sensors and a microphone. The conclusion from these experiments was that all of the sensors couldn't provide a solution the way we wanted them to, so eventually we decided to use conductive fabric for our interaction. The prototypes senses where you touch it through a matrix of patches with conductive fabric (figure 20). Our initial idea was to use silk instead of conductive fabric because silk is very pleasant to the touch, and it is also a conductor. However, silk proved to be less effective, because the conductivity is quite low. Therefore we decided to go for conductive fabric instead. We use the same principle as a 'Makey Makey', where you connect a negative and a positive patch together through your body, creating a circuit where current can flow through.[21]

Since your body has conducting properties, we can measure the variable resistance of your body, meaning that we can measure and determine even how hard the patches are touched. These inputs are translated into positions of a stepper motor, moving the servo to the position where you touch it, where then the servo will start it's movement, giving the same sensation of the midterm prototype where it feels like a baby kicking.

Hardware

The hardware inside the prototype also received a significant upgrade. The servo was upgraded from a S3003 Servo [22] to a TD-8130MG Waterproof Digital Servo that could withstand a load of 30 kg [23]. The S3003 Servo made a lot of noise in the midterm prototype, so the TD-8130MG is more powerful, making it less noisy when a force is applied on the arm, taking away one of the aspects that made the prototype too artificial. For the positioning of the servo arm we use a NEMA17 stepper motor, with a step degree of 1.8 degrees.

To determine the position of the hand of the user, we use 6 analog inputs, of which the configuration can be found in figure 21. While experimenting with the inputs, we noticed that each of the analog inputs also had a small influence on the other ones. Therefore we use 4 0.47 µF capacitors to smooth the signals.

Analog pins 4 and 5 don't have a capacitor, because the communication with the Adafruit Motorshield [25] is done via these analog pins. In order to provide enough power to the motors and the arduino, we use a separate power supply for the motors and for the arduino. The arduino is powered through the 5V USB port of a laptop, and the motors through a 12 V 1A external power supply. You can find the arduino code in appendix E, and additional pictures of de building in appendix F.

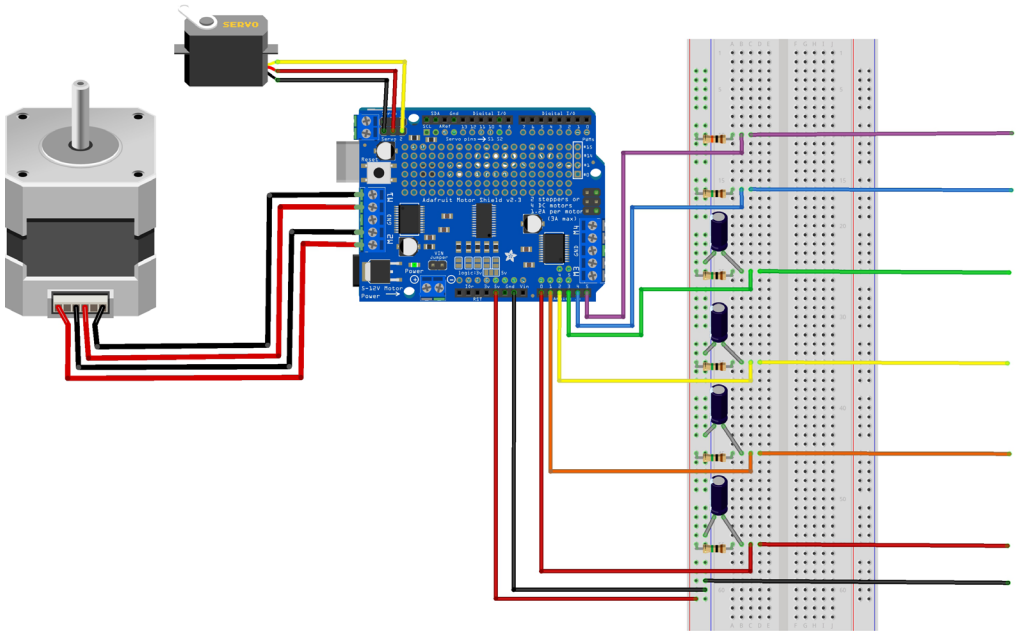


Figure 21. *Schematic of the hardware inside prototype 2.*

Second Iteration - Evaluation

Evaluation Session

After the realisation of this second version of our prototype, we looked at different online forums to talk to mothers and get their opinion in order to evaluate this new prototype. This is how we came into contact with a pregnancy coach from Zalig Zwanger, a mother of two herself.

We arranged a meeting with her since she has a lot of experience with pregnant women, and thus could speak for a large group of pregnant mothers, she could make valid evaluations for us. Once again a semi-structured interview was conducted, and during the interview the coach also filled in the same user journey we used for the previous evaluation session (see appendix C). We used a de-naturalist transcription method for the analysis of this interview [25].

Our main insights from the semi-structured interview that we took into consideration for the final concept are highlighted to the right.

- The movement has successfully become more natural and creates a strong emotional response: “The sound and the feeling of the pressure is exactly like I had it during my pregnancy, especially when I put my hands on my belly. I immediately got shivers when I heard the sound of the heartbeat, because I can also recognise it from my ultrasounds.”

- The triangular patches should be altered to feel more natural, soft, and pleasant to touch: “I don’t recognise the feeling of touching the top of the prototype. The triangles are too pointy because of their thickness and the difference in height to the fabric. The edge of the top is also too harsh, both that and the top doesn’t feel natural. The side does feel nice, it feels soft and like a belly when a pregnant woman is relaxed. The prototype needs to be something that I can have contact with.”

- The current shape does not allow for cuddling even though that can be a request by users: “I wanted to pull the prototype closer to my body and hold it against me, I think I instinctively pulled it closer.”

Figure 22. *A picture taken during the evaluation session, the pregnancy coach is experiencing the prototype.*

Final Prototype

Illustration of Prototype Layers

A: Conductive fabric to sense if the user is touching the surface. This area is the only one that allows interaction.

B: Stretchable fabric on which the conductive part is placed on.

C: A tube to maintain the structure: In order to soften it's hard edges, we used a viscoelastic foam that is soft to the touch, and it actually changes in softness to longer you touch it. The transducer is attached to the tube and lets the fabric vibrate to the heartbeat the user is hearing, aimed to make the experience more immersive.

D: Plate on which the robot-arm is placed on. This part can be changed according to the sensations the designers want to give and the tube gives enough room to place the electronics and actuators underneath.

E: Base with the stepper motor responsible for the rotational movement. On this level all the electronics are installed.

F: Ground Plate on which the fabric is attached to.

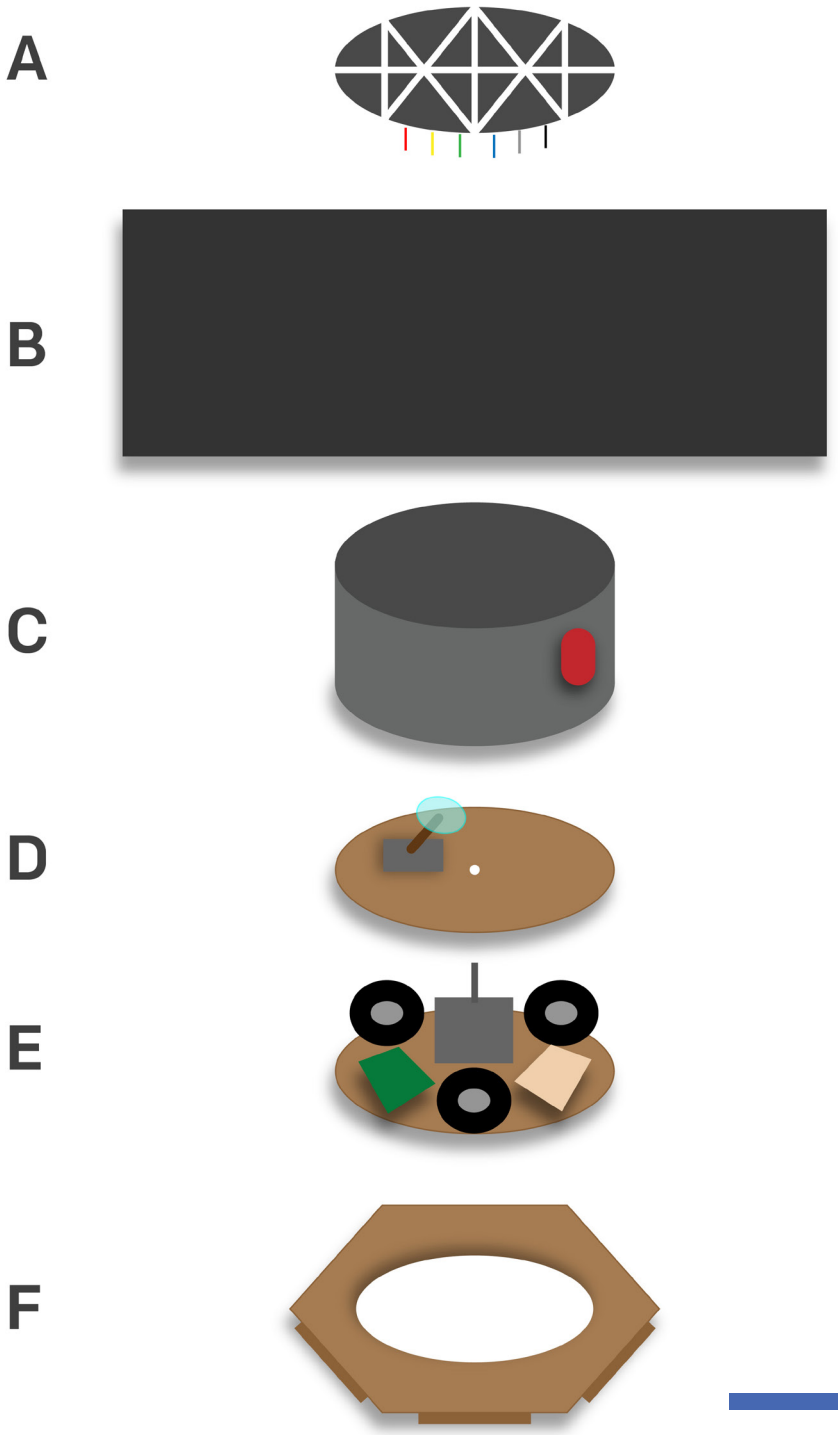
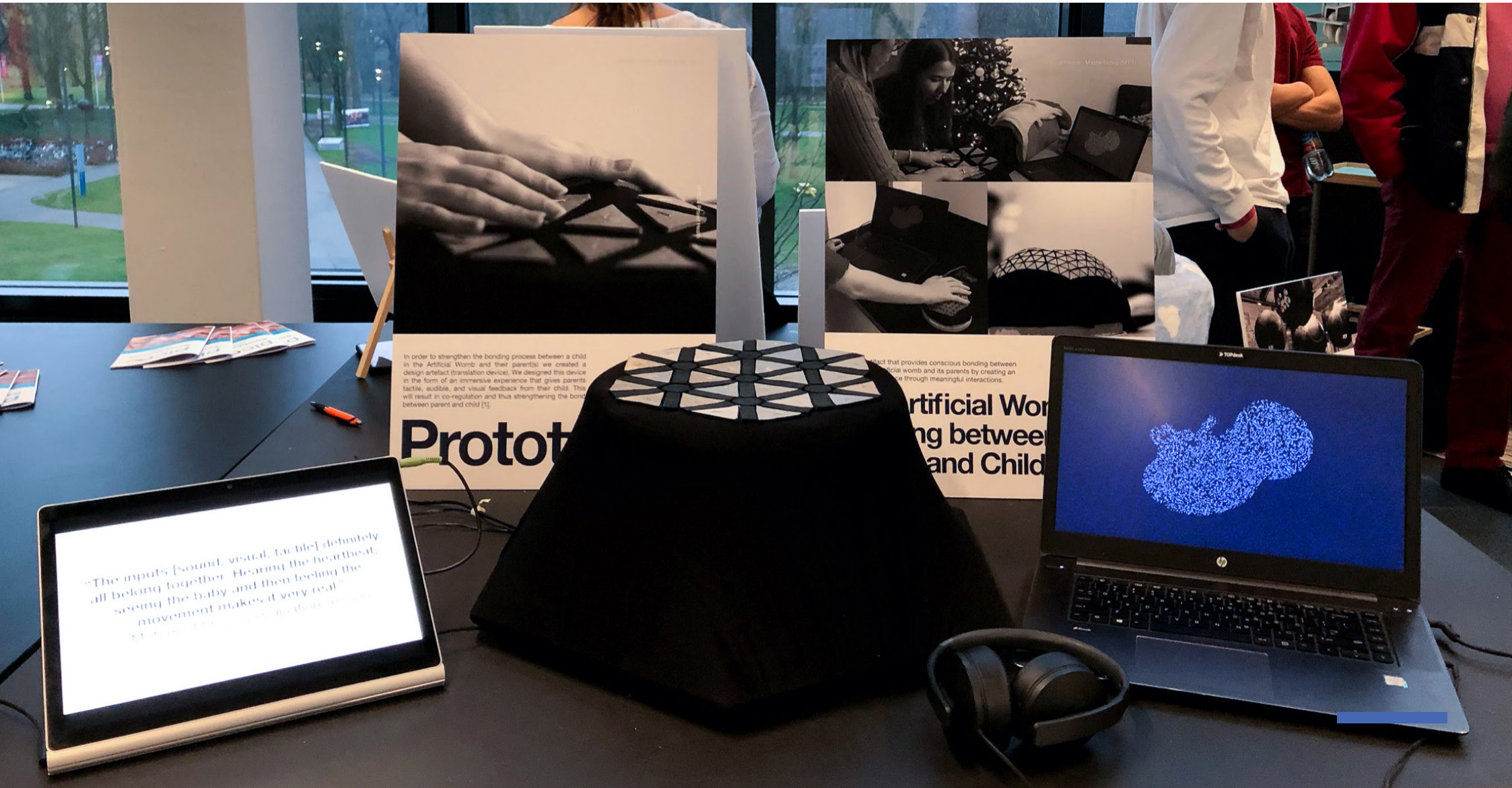


Figure 23. *An exploded view of the prototype with the different parts inside.*

Figure 24. *Our demo day setup. Pictured are all three prototypes, our posters, and a small screen with a collection of quotes gathered during our evaluation of the prototype.*



Discussion

We are aware of all the ethical dilemmas related to the artificial womb. A lot of implications about the artificial womb need to be investigated and evaluated by multidisciplinary themes. Policies have to be developed, as well as strict regulations about how the artificial womb can and should be used. However, the scope of this project was to envision a future scenario where the artificial womb would exist, and how we envision the interaction between parents and their child in the artificial womb.

Even though the feedback was positive all around, a long term evaluation has yet to be conducted. Bonding is a very complicated and long-term process, and can only be properly evaluated over a timespan of years. Since our evaluation only lasted an hour, we cannot really indicate any implications of the concept on the act of bonding. By testing over a longer period of time, we can get rid of the initial 'wow-factor' and bias, resulting in a more reliable evaluation.

The concept and prototype also have some flaws. Both the materials, interaction and overall experience should be enhanced. This will be further elaborated on in the next section.

Figure 25. *One of the students experiencing all three prototypes at the same time.*

Future Work

We realized that during this project we touched upon multiple unexplored design spaces and that in future work some factors influencing the design need further evaluation. In the case of conducting proper design research a focus on longitudinal studies should be considered to evaluate as well on the initial enthusiasm we observed during the interviews and user tests. This can lead to conclusions based on biased data.

We came across many questions from various perspectives ranging from micro to macro level. Regarding the non visual communication, on which the prototype was focused, we noticed that there are many ways to communicate by touch and that the technical possibilities are depending heavily on the placement and size of the design. We have not explored what would happen if we would use an abstraction rather than the realistic representation, but could offer a broader experience. Additionally, we propose to focus on the overall experience, which can be influenced by, for example:

- Material
- Context
- Colours
- Visuals
- Interactions
- Information Management
- Interface
- Service Design Thinking

Conclusion & Acknowledgements

Conclusion

The artificial womb offers the solution to many problems and implications that happen to premature children and their families as a cause of early birth. But as mentioned in the problem statement, it also let's new questions emerge. Like what will be the role of the parents in this new situation with a child in the artificial womb? This made it the goal of this project to: Design an artifact that provides conscious bonding between baby in the artificial womb and parents by creating an experience through meaningful interactions.

This resulted in a designed immersive experience that gives parents tactile, audible, and visual feedback from their child in the artificial womb Because this results in co-regulation it will unconsciously strengthen the bond between parent child!

In this future situation we expect new parents will receive their own room in the hospital in which also the artificial womb is placed, similar to the situation with an incubator now. The biggest difference being that now the baby is in the artificial womb the parents won't be able to touch, hear, or even see their baby for weeks.

Luckily this installation will be placed next to the artificial womb and provide the parents with real time information from inside the artificial womb the current heartbeat, the movement and an abstract visualisation of the current position of the child. Providing parents with that sense of togetherness again. The device can also be placed at home so even here the new parents can take a moment during the day to stand still and have a meaningful connection with their baby far away.

Does this mean our goal is met? We have no proof this particular immersive experience will create enough co-regulation to actively strengthen the bond between parent and child. To proof this a longitudinal study would be needed, as well as a larger test pool. We however do have proof that there is interest in the device and that experts in the neonatal and pregnancy field recognize it's potential.

During our process we spoke to different stakeholders and experts amongst which; mothers, pregnancy coaches and NICU experts. We spoke about the concept and here it was clearly visible how strong the immersive experience can be. Multiple of the mothers got emotional during the experience. One of them commented on how hearing the heartbeat and feeling the movement immediately transported her back in time to the, for her, magical doctor visits during pregnancy where she would get to hear and see her baby on an ultrasound.

"The sound and the feeling of the pressure is exactly like I had it during my pregnancy, especially when I put my hands on my belly. I immediately got shivers when I heard the sound of the heartbeat, because I can also recognise it from my ultrasounds."

And a pregnancy coach was happy to see how we laid our focus on the needs of the parents, as in situations like this all the focus tends to go to the health of the child. But co-regulation is a two way process and the mental health of the parents is a serious topic that should not be underestimated. She thought it was wonderful how we seemed to give parents that little bit of control and empowerment back. Creating a new role for parents in the future situation with a child in the artificial womb.

"There is such a fear involved [in premature birth]! And that is really fear that is about life and death. Then it would be very nice if there is attention for it! For

This leads to us believing this experience shows a lot of potential in helping parents with a child in an artificial womb. Sharing real time knowledge about the wellbeing of their child with them and providing them a moment of calmth and relaxation that leads to subconscious co-regulation. So yes, our goal is met. However there is always room for enhancement, you can read more about this in the discussion and future work chapter.

Acknowledgements

We would like to take a moment to thank the coaches and students of the Health squad for their support, and guidance. In particular we want to thank Peter Peters, Frank Delbressine, and Roos van Berkel for their valuable feedback throughout our process. Thank you for your flexibility, inspiring words, actions and encouragement.

Secondly, this project was also supported by Mrs. Wong from ‘Zalig Zwanger’, Mrs. Kommers from ‘Maxima Medisch Centrum’, and Mrs. Van den Oever from ‘Trescoaching’. Thank you all for the pleasant cooperation, provided insights, and connections. Thank you for taking the time to brainstorm with us, your valuable and constructive feedback on the concepts inspired us.

At last we want to thank the mothers and pregnant women who let us into their lives and openly shared their experiences with pregnancy and motherhood. Your stories allowed us to get a better understanding of what a family goes through during the transition into parenthood. How strong emotions can get when it comes to the wellbeing of your children and why it is so important to provide support to parents in this life changing situation to result in a healthy parent-child relationship.

Thank you for reminding us why working on this topic is so important.

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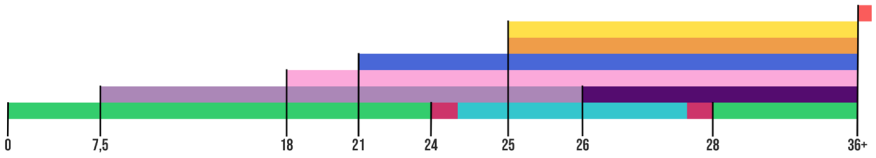
Appendix A: Timelines

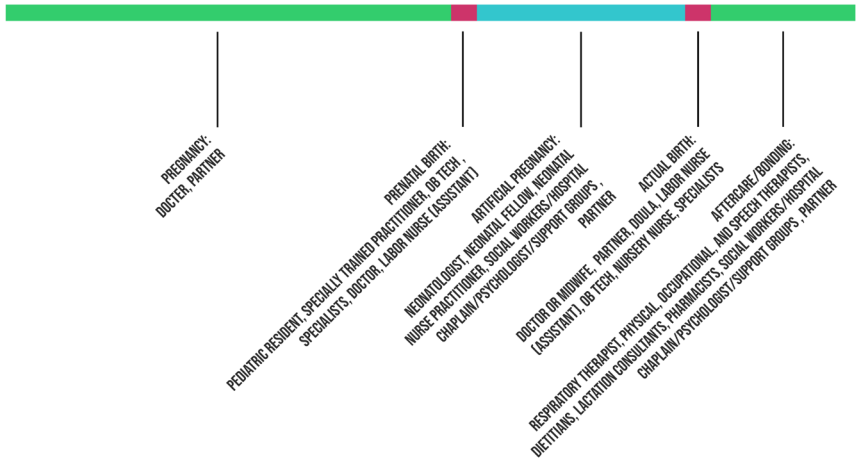
DEVELOPMENT TIMELINE



VISUAL DEVELOPMENT (FULLY DEVELOPED AT 36+ WEEKS)
AUDITORY DEVELOPMENT (FULLY DEVELOPED AT 25 WEEKS)
SMELL (FULLY DEVELOPED AT 25 WEEKS)
VESTIBULAR DEVELOPMENT (FULLY DEVELOPED AT 21 WEEKS)
TASTE (FULLY DEVELOPED AT 18 WEEKS)
SKIN DEVELOPMENT (FULLY DEVELOPED AT 26 WEEKS)

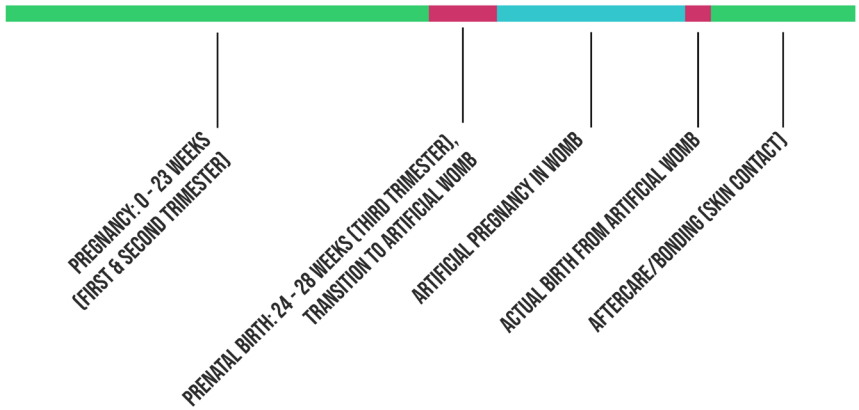
BIOLOGICAL/DIRECT (SKIN) CONTACT
TRANSITION/BIRTH
ARTIFICIAL PREGNANCY (WOMB)

STAKEHOLDER INVOLVEMENT TIMELINE



BIOLOGICAL/DIRECT (SKIN) CONTACT
TRANSITION/BIRTH
ARTIFICIAL PREGNANCY (WOMB)

NEONATAL PREGNANCY TIMELINE

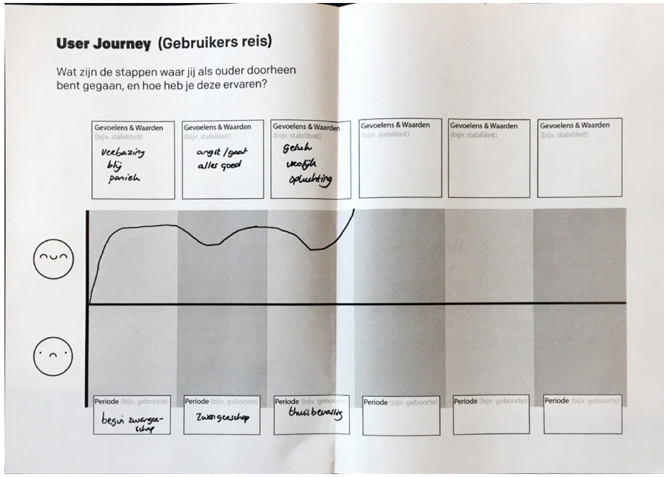


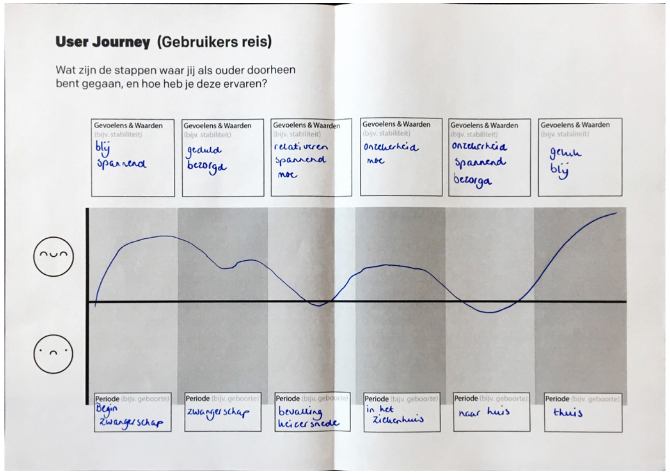
BIOLOGICAL/DIRECT (SKIN) CONTACT
TRANSITION/BIRTH
ARTIFICIAL PREGNANCY (WOMB)

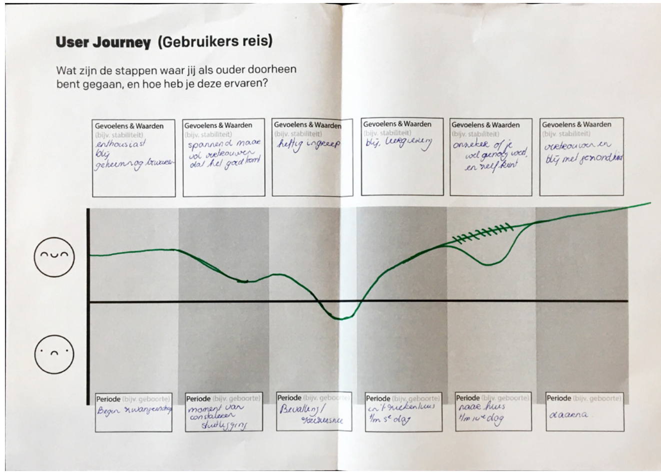
Appendix B: Processing code

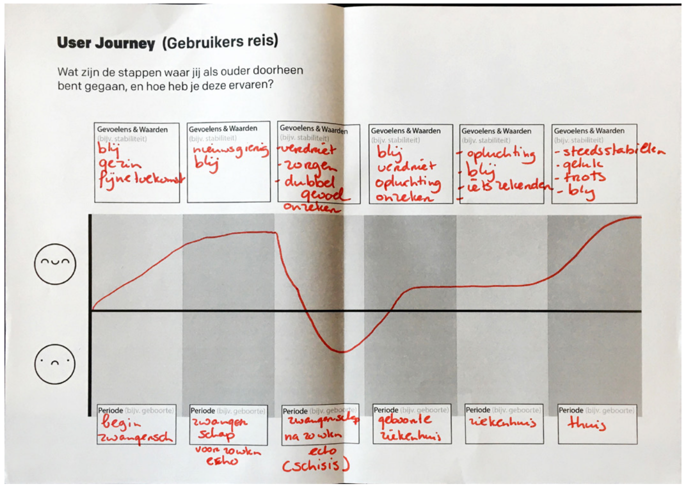
```
PImage baby;

Rectangle[] rectangles = new Rectangle[30000];

void setup () {
 fullScreen();

 baby = loadImage("Background.png");
 baby.loadPixels();

 for (int i = 0; i < rectangles.length; i++) {
  rectangles[i] = new Rectangle();
 }

 println(width);
 println(height);
 println(baby.width);
 println(baby.height);
}

void draw() {
 background(25, 30, 40);

 loadPixels();

 for (int i = 0; i < rectangles.length; i++) {
  rectangles[i].display();
  rectangles[i].movehorizontal();
  rectangles[i].movevertical();
 }
}

class Rectangle {
 float x;
 float y;

 float speed;

 boolean mouse;

 boolean inBaby(float x, float y) {
  return baby.pixels[ int(x) +baby.width*int(y)] == color(0, 0,
0);
 }

 Rectangle() {
  x = random(0, width);
  speed = random(0.1, 0.5);
  y = random(0, height);
  mouse = false;
 }

 void display() {

  if (x < baby.width && y < baby.height) {

   if (inBaby(x, y)) {
    fill(84, 97, 141);
   } else {
    fill(25, 30, 70);
   }
   noStroke();
   //ellipse(x, y, 4, 4);
   rect(x, y, 4, 4);
  }
 }

 void movehorizontal() {
  x = (x + speed) ;
  if (x > width) x = 0;
 }

 void movevertical() {
  y = (y + speed) ;
  if (y > height) y = 0;
 }

 void hover(int mx, int my) {
   if (x > width/4 && x < 3*width/4 && y > height/4 && y <
3*height/4)
    mouse = true;
  else {
   mouse = false;
  }
 }
}
```

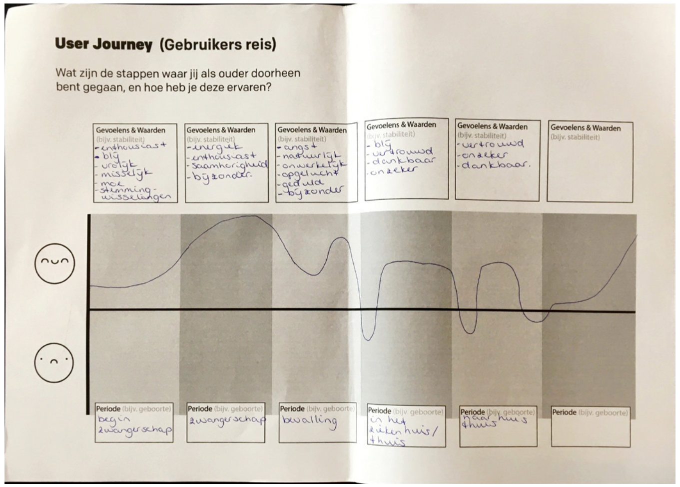
Appendix C: User Journeys

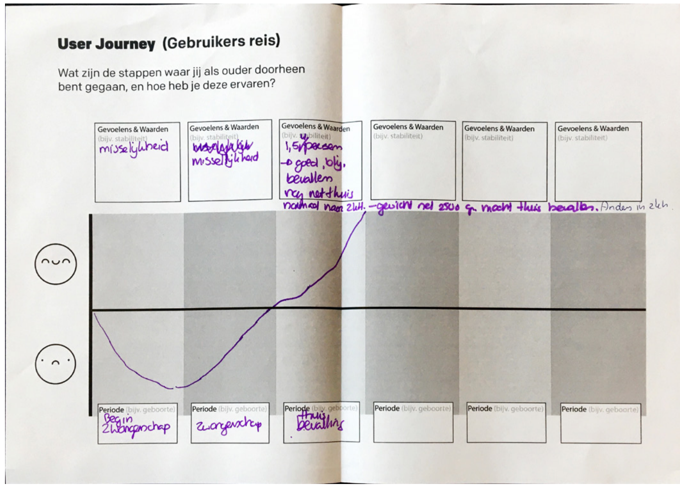












Appendix D: Transcripts

See transcript at the end of the document.

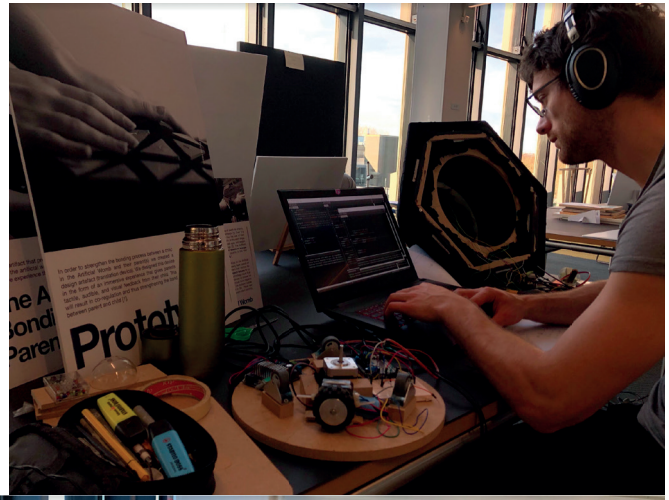
Appendix E: Arduino Code Prototype 2

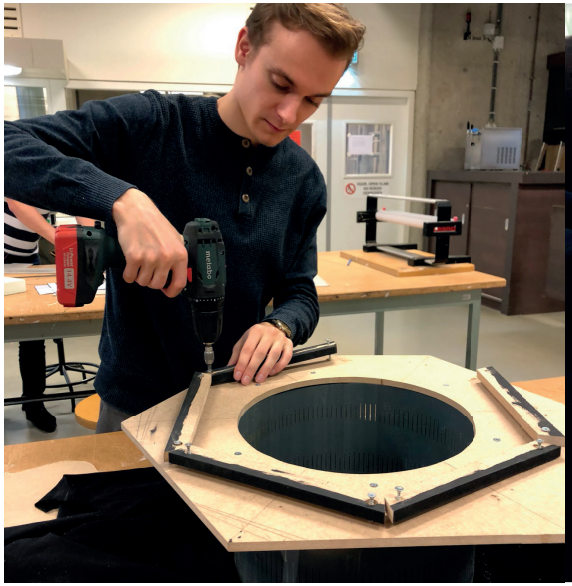
```
#include <movingAvg.h>
#include <Servo.h>
#include <AccelStepper.h> //accelstepper library necssary to control the stepper
#include <Wire.h> // communication protocol to communicate with the motorshield
#include <Adafruit_MotorShield.h> // the motorshield library

Adafruit_MotorShield AFMStop(0x60); // Default address, no jumpers
Adafruit_MotorShield AFMS = Adafruit_MotorShield(); // create a motorshield object
Adafruit_StepperMotor *myStepper1 = AFMS.getStepper(200, 1);
Adafruit_StepperMotor *myStepper2 = AFMS.getStepper(200, 2);

Servo myservo180;
int pos = 40;

int pospatch1 = 0;
int patchdifference = 33;

// Original values were 200 and then 600
const int PressedMaxThreshold = 600;
//const int ReleasedMinThreshold = 300;
const byte PinCount = 6;

long timer = millis();
long timer2 = millis();
long timer3 = millis();

const byte InputPins[PinCount] = {A0, A1, A2, A3, A4, A5};
const char KeyCodes[PinCount] = {'A', 'B', 'C', 'D', 'E', 'F'};


struct TouchInput
{
 byte analogPin;
 char keycode;
 movingAvg filter = movingAvg(20);
 boolean wasPressed = false;
};


TouchInput Pins[PinCount];



//setup for motors
void forwardstep1() {
 myStepper1->onestep(FORWARD, INTERLEAVE);
}
void backwardstep1() {
 myStepper1->onestep(BACKWARD, INTERLEAVE);
}
// wrappers for the second motor!
void forwardstep2() {
 myStepper2->onestep(FORWARD, DOUBLE);
}
void backwardstep2() {
 myStepper2->onestep(BACKWARD, DOUBLE);
}

//transfer to accelstepper object
AccelStepper aStepper(forwardstep1, backwardstep1);
AccelStepper aStepper2(forwardstep2, backwardstep2);


int  servEnd = 100;
int pad[4];
int m;
int posDiff = 60;
int number;
int number2;

////////////Code start

void setup()
{
 Serial.begin(115200);
 myservo180.attach(9);          //9 are the 3 pins on the inside, 10 are the 3 pins on the outside
 setupstepper();
 pinMode(LED_BUILTIN, OUTPUT);
 myservo180.write(20);
 for (int i = 0; i < PinCount; i++)
```

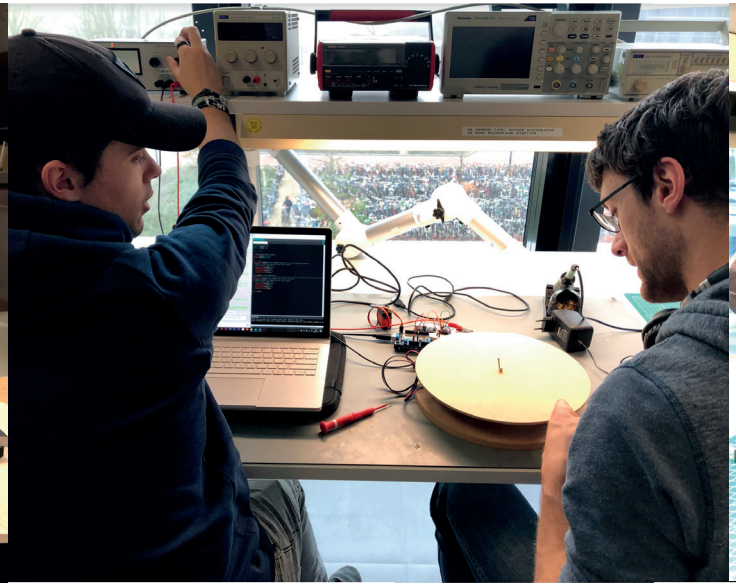
```
{
  Pins[i].analogPin = InputPins[i];
  Pins[i].keycode = KeyCodes[i];
  Pins[i].filter.begin();
 }

}
void loop()
{
 loopstepper();


 // timer3 generating random numbers for later use
 if (timer3 < millis()) {
  timer3 = millis() + 5000;
  number2 = random(60, 100);
  number = random(0, 200);
  Serial.print(number);
  Serial.print(",");
  Serial.print(number2);
  Serial.println(" ");
 }


 // pin check event
 if (timer < millis()) {
  timer = millis() + 20;

  m++;

  digitalWrite(LED_BUILTIN, !digitalRead(LED_BUILTIN));


  //check pins
                float currentAverage = Pins[0].filter.
reading(analogRead(Pins[0].analogPin));
                float currentAverage1 = Pins[1].filter.
reading(analogRead(Pins[1].analogPin));
                float currentAverage2 = Pins[2].filter.
reading(analogRead(Pins[2].analogPin));
                float currentAverage3 = Pins[3].filter.
reading(analogRead(Pins[3].analogPin));
                float currentAverage4 = Pins[4].filter.
reading(analogRead(Pins[4].analogPin));
                float currentAverage5 = Pins[5].filter.
reading(analogRead(Pins[5].analogPin));

  //    boolean previousState = Pins[i].wasPressed;
  //     boolean currentState = previousState; // Default if in
the dead zone

  /*
    Serial.print(currentAverage);
    Serial.print(" ");
    Serial.print(currentAverage1);
    Serial.print(" ");
    Serial.print(currentAverage2);
    Serial.print(" ");
    Serial.print(currentAverage3);
    Serial.print(" ");
    Serial.print(currentAverage4);
    Serial.print(" ");
    Serial.println(currentAverage5);
  */



  //save pin state in array
  if (currentAverage < PressedMaxThreshold) {
   //do something when patch 1 is touched
   //Serial.println("Touching button A0");
   pad[0] = 1;
  } else {
   pad[0] = 0;
  }
  if (currentAverage1 < PressedMaxThreshold) {
   //do something when patch 2 is touched
   //Serial.println("Touching button A1");
   pad[1] = 1;
  } else {
   pad[1] = 0;
  }

  if (currentAverage2 < PressedMaxThreshold) {
   //do something when patch 3 is touched
   //Serial.println("Touching button A2");
   pad[2] = 1;
  } else {
   pad[2] = 0;
  }

if (currentAverage3 < PressedMaxThreshold) {
   //do something when patch 4 is touched
   //Serial.println("Touching button A3");
   pad[3] = 1;
  } else {
   pad[3] = 0;
  }
 }

 //actual event triggering timer
 if (timer2 < millis()) {
  timer2 = millis() + 500;

  //check values of array and trigger event
  if (pad[2] == 1) {
   aStepper.moveTo(-(posDiff * 4) * 0);
   aStepper2.moveTo(posDiff * 0);
   if (aStepper2.distanceToGo() <= 5) {
    myservo180.write(servEnd);
    //aStepper.stop();

       myStepper2->release();    //this funciton needs to be
called otherwise one motor is constantly taking 1A, which
would potentially harm the the motor shield
   }
   if (aStepper.distanceToGo() <= 5) {
    myStepper1->release();
   }
```

```
 } else if (pad[1] == 1) {

   aStepper.moveTo(-(posDiff * 4) * 1);
   aStepper2.moveTo(posDiff * 1);
   if (aStepper2.distanceToGo() <= 5) {
    myservo180.write(servEnd);
    // aStepper.stop();
    myStepper2->release();
   }
   if (aStepper.distanceToGo() <= 5) {
    myStepper1->release();
   }

  } else if (pad[0] == 1) {

   aStepper.moveTo(-(posDiff * 4) * 2);
   aStepper2.moveTo(posDiff * 2);

if (aStepper2.distanceToGo() <= 5) {
     myservo180.write(servEnd);
     // aStepper.stop();
     myStepper2->release();
   }
   if (aStepper.distanceToGo() <= 5) {
     myStepper1->release();
   }

  } else if (pad[3] == 1) {

   aStepper.moveTo(-(posDiff * 4) * 3);
   aStepper2.moveTo(posDiff * 3);
   if (aStepper2.distanceToGo() <= 5) {
    myservo180.write(servEnd);
   }
   if (aStepper.distanceToGo() <= 5) {
    myStepper1->release();
   }

  } else
     //if more than one pad is touched then move around in a
random fashion
    //at this point more concrete events could be triggered for
specific inputs
    if (pad[0] + pad[1] + pad[2] + pad[3] >= 2) {

      aStepper.moveTo(-(200) * 4 );
      aStepper2.moveTo(200);
      myservo180.write(number2);
      if (aStepper2.distanceToGo() == 0) {
       aStepper.moveTo(0);
       aStepper2.moveTo(0);
      }
      Serial.println( aStepper2.distanceToGo());

    }


  // this value resets the servo arm to its default position
  if (m >= 150) {
   myservo180.write(30);
   m = 0;
  }


  Serial.print(m);

Serial.print(",");
  Serial.print(pad[0] + pad[1] + pad[2] + pad[3]);


  //print pad array
  for (byte k = 0; k < 5; k = k + 1) {
   Serial.print(pad[k]);
   Serial.print(",");
   if ( k == 4) {
    Serial.println(" ");
   }
  }
   }
}

void setupstepper() {
 AFMS.begin(); // start the motorshield
  aStepper.setMaxSpeed(500.0); // in this mode the stepper
automatically
 // accelerates to a max speed, this is the max speed
 aStepper.setAcceleration(200.0); // this is the accelation

aStepper2.setMaxSpeed(250.0); // in this mode the stepper
automatically
 // accelerates to a max speed, this is the max speed
 aStepper2.setAcceleration(40.0); // this is the accelation

 }
 void loopstepper() {
 aStepper.run();
 aStepper2.run();
 }
```

Appendix F: Pictures of Building







Individual Reflection - Rick Buijs

I chose to partake in the artificial womb project because I personally love far-future projects. They're a big passion of mine, and I already had some experience doing projects that are more futuristic. I especially wanted to focus on using my Creativity & Aesthetics skills in combination with new knowledge in the Technology & Realisation field.

During this project my main responsibilities were as follows: I made sure that our reports and anything else we handed in looked cohesive and was written in correct English (I checked for grammar and sentence structure errors, as I'm a fluent speaker). In the ideation phase I took up a big part of the concepting as I had a lot of experience in it. This once again confirmed my thoughts on ideation and conceptualisation, reaffirming that it suits me really well and that this is something I want to focus on in the future of my master.

Before the midterm Nick and I realised the first version of the prototype, and made sure everything was ready for our midterm demo day. I designed the posters and directed the other mayor visuals for both demo days. This also helped to reaffirm my desire to pursue the Creativity & Aesthetics expertise area.

Because I wanted to learn more about Technology & Realisation, a goal for me was to understand that side of our prototypes. I wanted to be able to understand what was going on inside of the machines, so that I could design for and around it. I feel that I successfully did this by researching, designing and helping to realise both of the prototypes. Another example of this is working together with the rest of the team to make sure the final prototype would work with the technology, and then designing the outside together with Kyara and Maik with this technology in mind.

I also enjoyed supporting the other teammates with their work during this project, and noticed that I really enjoyed working in a group again. From time to time this included a lot of I-told-you-so's, but in the end I feel proud that I could share my knowledge with the other members of the project group.

I feel that as designer I had (and took) the opportunity to grow during this project. I learned a lot about motors, technology (such as increase knowledge in the Arduino department) and realising concepts into actual prototypes.

Because this was also a goal of mine that I recorded in my Personal Development Plan, I'm very happy that I got to experiment more with Technology & Realisation. Another goal I had set for myself was that I would figure out what Track would best suit me before the new project in M1.2. I feel as if I managed to gain more insights into the different tracks and expertise areas, and even though I'm not yet certain now I still feel as if I've taken steps towards that goal.

One of the differculties of this project was that we were dealing with a hypertheoretical project; there haven't been any users of the artificial womb. Ever. This made the project very freeing and enjoyable, but also challenging. I feel that as a group we managed to frame the target group and context to the best of our abilities.

What I also learned was that I don't need to do everything by myself. I usually live with the motto 'If you want something to be good, do it yourself'. During this project I mentally and physically understood that this is not possible when working on a big project like the artificial womb. I had to entrust certain things that I would have rather done myself to others, and for me personally this was a big development.

Individual Reflection - Kyara Fasen

At the start of this semester I formulated several goals for myself in my PDP, regarding professional skills (self-confidence, proactivity, recognizing my owns strengths) and my development in the expertise areas of this department (Involvement of users, building a physical prototype, laying focus on interaction). The design project I joined to realize these goals was focused on bonding in the artificial womb.

This subject spoke to me because it challenged me. The possibilities seemed endless, the context vague, it had no existing user group and it seemed to have a strong technology focus. All unlike the strongly user centered and psychology focused projects in my past.

But during this master I wanted to step up my game, and I got it.

The members of this team were all very different. Both in character and skills. But the collaboration between us worked flawlessly. We each had different strengths and were able to complete each other. I started this project with the personal goal to make sure I stand tall, have confidence in my ideas and make sure they are being heard even though I can find this challenging because of my own quiet and introverted nature. But during the past semester I was very well able to showcase my own strengths in ideation, conceptualization, and user involvement while learning from the others.

Especially regarding the involvement of users I took lead and was therefor able to teach the others about how to apply multiple new methods (e.g. user journeys, semi-structured interviews, and the thematic analysis) to the design process. But besides that, I was also able to develop myself in the 'user and society' expertise area (the area I want to specialize myself in during this master). Because working with a non-existing user group offered it's challenges. This was the first time I had to imagine a user through quasi similar user groups. Because of this quasi similarity the group of "users" in our evaluation sessions also needed to be assisted in empathizing with our actual user group and this gave us the challenge to dive deep in literature and learn how to achieve this during a session.

Secondly taking charge in the organization of this user involvement learned me how to get to my desired user group through the power of networking. Because it is such a vulnerable, and possibly emotional, topic it could be difficult at times to find qualified "users". But through reaching out to experts on online forums and through them again being able to access their network proved itself to work very efficiently (although also time consuming). Therefor I will make sure to reach out to potential users in future projects from the very start. To establish strong relations and have the time to make use of the full potential of their network if offered.

The two expertise areas that stand farthest from my comfort zone are 'Math, Data, and Computing' and 'Technology and Realization'. Meaning that these are the areas where I got to learn a lot from my other, more experienced, team members now I was involved in the work of this strongly technology driven project. Although this lead to me gaining a lot of new insides into both the hardware and software we worked with, my biggest learning point is that I now have a better understanding of the process behind it. Which is very valuable for future, individual projects, as it allows me to phrase my questions better.

In past projects I often ran into difficulties with prototyping and writing code, not understanding the well-meant suggestions or not knowing how to implement them lead to me often having to change the concept or taking a different direction than desired. But now I feel confident that because of the things I've learned this semester, because of all the ups and downs with our prototype and how we handled this, that these will be problems of the past.

To conclude, I'm happy to say I was able to complete all the goals I set for myself during this project far from my comfort zone. And it makes me exited for new, challenging and interesting projects in this squad next semester.

Individual Reflection - Maik Nothbaum

One of my learning goals was to learn more about design processes and the motivation to choose this theoretical and vague project. Because of this I learned to think how to relate and adjust methodologies such as a user journey to a theoretical design process and to create frameworks.

The efficiency of mood boards, sketches, storyboards have created a sense of orientation and at no point in the process have we been or felt totally lost, while facing great uncertainty about our decisions. It is very helpful to put thoughts on paper and have something to point at while talking.

Most importantly after the unfruitful literature research about all the biochemistry that occurs during bonding I have learned to shift my perspective and create a frame for the process by analysing/defining the context in which it is placed in. Through this I have improved my professional skill dealing with scientific information. This turned out to be more helpful than the other approach and helped us during the project in multiple ways and let us realise the emotional challenges the user could face, it even give us an idea how the design could archive to be meaningful with its experiences and interactions.

Through this we were able to empathise with a non-existing user group and validate our assumptions based on insights from quasi-similar contexts and scenarios. This will be helpful in my future projects and motivates me to specialise more on the underlying theory of design processes, because I see this as fundamental knowledge for design and will help me in any choice of my future designer career. Further, though this activity I could improve my expertise area “user and society” in ways I have not expected before.

It was as well the first project in which I could approach the discussion of meaning in a design, which are usually more fuzzy and vague. To be able to talk about this topic with sufficient confidence is something I perceive as another fundamental aspect in a design process and archived during this project. I don’t want to claim that our proposal is bulletproof, but the conclusions seem to be promising and something I will keep in mind for the next project.

I could improve my technology and realisation skill by planning and constructing the physical aspect of the prototype. Here I could include the aspect of flexibility from my identity as a designer in the construction. When you look back at the construction of the overall piece you will find that the actual motors providing feedback can be replaced with other technical possibilities and offers the possibility to conduct research with the “Wizard of Oz” technique. The way the project turned out I had not a chance to meet my goal to improve my Math, Data and computing skills further, but I don’t see that as a major disadvantage, because I am currently working on this in an elective.

The collaboration in the team went good. We enjoyed to see the benefits of healthy differences in opinions within our team and has improved the overall communication throughout the project. Further, in this project I was able to see that the weaknesses I have showed at the beginning of my bachelor during group projects are gone by now. I know now how to communicate criticism and state my views in a way that my group members see it as an invite for further discussion instead of a call for conflict. Further, now I know how to raise questions that are not only relevant for the process, but as well remain unanswered to indicate the unknown the process is surrounded by.

Individual Reflection - Nick Ruijs

At the start of this semester I formulated two main goals for this project in my Personal Development Plan. In this reflection I will evaluate these goals and if I achieved them during this project.
The first goal was: “How to handle a highly conceptual context and provide meaningful insights.” In order to be able to operate in an academic setting, you need to be able to handle a highly complex and sometimes conceptual context. Since the artificial womb doesn’t exist yet, we needed to make educated assumptions about the design space. It was also impossible to interview or talk to our target users because they simply don’t exist yet. I said that I would consider this goal as achieved when the result of this project actually provided new insights that hadn’t been explored yet. I think that I can safely say that we did achieve exactly that. During our evaluation of the second iteration, all the responses that we received by the experts, professors and fellow students were highly positive. One of the implications that we discovered is that tactile/ haptic interfaces, together with audible and visual cues can aid in conscious bonding between mother and child.

However, these implications are only based on the few interviews that we did. I do realize that these implications need to be put into perspective, because the concept has not been tested over a longer period of time. However, I am satisfied with the results and the way we handled the context, So I still consider this goal as achieved. The most important thing I learned here was that if you don’t know what your context is, or it simply doesn’t exist yet, you should look for a context that comes the closest to what you are looking for, in this case the Neonatal Intensive Care Unit environment (NICU). In this way you can make assumptions based on relatively similar information but realizing that your information is indeed based on assumptions is vital here. In this way you are able to distinguish between facts that can be proven, and facts that are biased and ‘made up’.

The second goal was: “How to prototype the impossible”. I did realize that actually making and building the artificial womb would be an impossible challenge for me at this stage of my education. However, I wanted to try to come close to it, not in terms of functionality, but in terms of experience. Since no one has ever experienced the artificial womb, I wanted to explore the possibilities in actually prototyping the experience without having to build the actual artificial womb itself.
The challenge we formulated as a group was “designing an artifact that aims to support/aid interaction exploration with the artificial womb to provide natural bonding with unborn babies.” I said that I would consider this goal as achieved when I created at least 1 prototype that allowed for exploration in interaction.

During the design process, the design shifted a lot, moving away from being a tool that allowed exploration, towards a prototype that would actually function as a proof of concept, but still providing a good experience and interaction. If I would strictly follow my own boundaries, I did not achieve this goal. However, I do feel like I did. Our concept was aimed towards the bonding between mother and child in the artificial womb, and we wanted to provide an experience of something that didn’t exist yet. The feedback that we got was so positive, that I will argue that we achieved exactly that. Not only were we able to provide a meaningful experience, we actually came close to how we envision the future of the artificial womb. During the prototyping process, I learned a lot about actuation and mechanical hardware. I had never used such powerful servo and stepper motors before, and I had never done such complex actuation in a prototype. I also learned more about analog readings and signal processing, for example different smoothing techniques such as using capacitors, running averages, and how to use these analog readings for actuation.
To conclude, I’m really happy with the project and the things that I learned during this complicated but interesting process.