

NEW FUTURES SQUAD

FENG



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ABSTRACT

In this report, the design approach and decisions leading to the concept of Feng are described. Feng is a concept meant to sonify the air quality within the house. Getting its inspiration from traditional wind chimes, the system forms a relationship between sound and air, and it speaks the language of nature in communicating this relationship. The system plays a harmonious sound, with different undertones to communicate potential problems with the air quality in each room.

INTRODUCTION

This report describes the design process and the result of a project group from the 'New Futures – Connectivity in the Home with Energy, Systems and Sound' squad of the Industrial Design department of the Technical University of Eindhoven. This project group focused on the sound and multimodal interactions of a smart home of a mundane family going by the name Zander.

The project takes a closer look at soundscapes in the homes of the future and communicates the body language of the house through sound with a specific focus on air quality. The goal of the project is thus established as following:

'Design an interactive system that allows for communication of the air quality within the home through its soundscape'



figure 1: Close-up of the nodes of Feng

This report describes the process leading to the creation of Feng. Feng is a concept that aims to sonify the qualities of air within the house. With its inspiration coming from traditional wind chimes, Feng forms a relationship between sound air and nature. The sounds it generates create a language of nature to communicate with the inhabitants of the house. Feng as an object is the symbolism of the house with a centerpiece built around nodes that represent specific rooms in the house. It welcomes the inhabitants to interact and speak with it via swinging or moving these nodes. The system plays a harmonious sound, with different undertones to communicate potential problems with the air quality in each room. The nodes change in height depending on the urgency of the problem they represent. Through the relative difference in height created by motion, the Feng invites the user to interact with the system. The harmonies are played through the speaker system throughout the house and the location of the problem is communicated through the directional properties of sound.

PHASE 1: EXPLORATION OF TOPICS & IDEATION

When faced with a new design challenge, everyone immediately forms associations about the topic. However, different people have different ideas, so the importance of the first stage was focused on communicating these prejudices, personal goals, and design opportunities with each other.

Making sketches during this first broad exploration was essential to the process as it shaped the groups way of thinking to come up with the final concept. before getting to this concept later in the report, there are some useful milestones in this phase to talk about, and some of the most influential sketches will accompany the text. If there is interest in all influential sketches of this phase, they can be found in Appendix A.

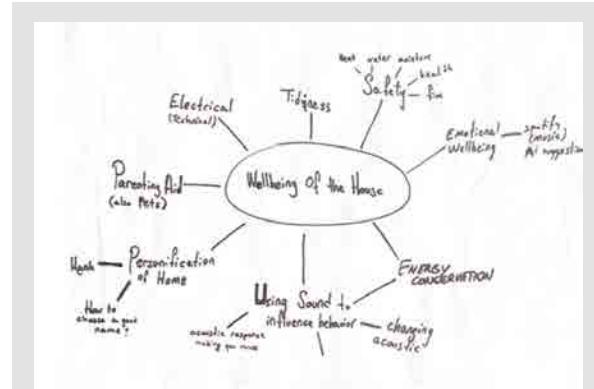


figure 2: Wordweb on initial brainstorm

As a starting point, a wordweb were created of what a smart product could be able to do in a home-environment, one of which can be seen if figure 2, providing a common understanding within the group to increase the efficiency of all concepts generated after that point. As the final product is bound to be placed in a home from the future, sustainability is of course important, but it was decided early-on that if this topic was going to be utilized, it shouldn't just become an elaborate way to prevent people from certain activities to be sustainable, but making the product part of the ritual involved in these actions.

One of the first concept-groups that originated from this consisted of concepts that created sound passively alongside the user, such as a room in which the acoustics stimulated inhabitants to sit close to the heating or a shower creating noise tied to excess water usage (figure 3). Yet a more explicit description of what a smart product should be was generated:

'A device that senses (part of) its surrounding and can make decisions based on these sensed qualities and (learned) priorities, as well as convey these made choices to the user via actions or other feedback.' In the first concepts it would be difficult to implement a level of interaction that was more extensive than only an action that had a set reaction.

Thus, the following concept concerned a product replacing the walls in the home through motorized sound-insolation, making walls 'solid' or 'transparent' to allow a smoother interaction and socialization between inhabitants, a sketch and summary of the functionality is shown in figure 4.

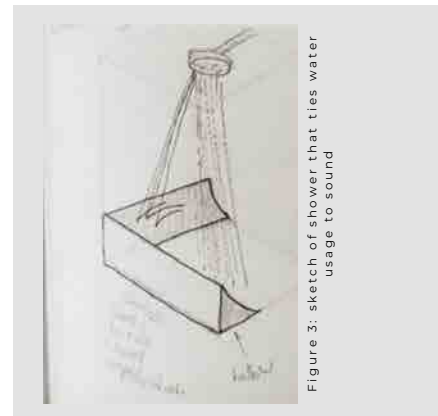


Figure 3: sketch of shower that ties water usage to sound

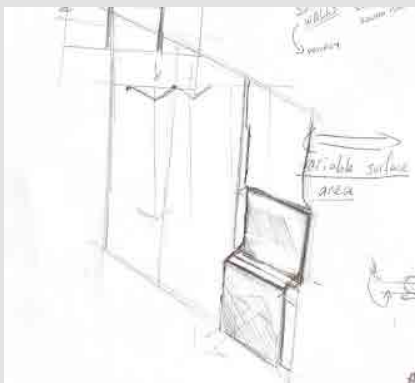


Figure 4: sketch motorized sound-proofing wall

This brainstorming sequence, however, got carried away as being too detail oriented, requiring a step back in favor of a broader approach. In hindsight, the paper [4] where a workshop aimed at brainstorming the future of sonification in products is described, follows a similar structure to the progress that was made in these first phases. One of the realizations the group came to was also brought up in the aforementioned paper, sound is often only used when a product holds so many functions that a screen cannot properly convey all this information. However, even in scenarios where simple information is conveyed, sound may offer additional convenience and fluidity to the interaction.

The methods of conveying information sonically included a directional sound guiding the user, linking distance to time; both using the advantages sound offers over a traditional screen-based interface. Adding the auditory sense allows for better integration in a busy home environment, while not distracting inhabitants from visually seeing what they are doing. Within this exploratory phase, the shards of ideas and knowledge coming from the paper and experience were utilized to come up with a more concrete "next concept". Having defined smart devices within the scope of the project and concluding utilization of sound as an information-carrying message is efficient and manageable, allowing for a confident general direction towards the future. The next goal is to determine a specific direction and make solid decisions on the framework of the project.

PHASE 2: FIRST CONCEPT

Within this early phase of the project, exploration and out-of-the-box thinking was emphasized to create an abundance of concepts. Many ideas were initialized and while that offered a great variety of designs to focus on, they had to be narrowed down. By looking at the unique ways users can interact with sound in contrast to other ways of interaction design, the scope of the project was narrowed down to align with the design case.

A unique thing about the interaction with sound is the fact that it can quickly communicate a message to a user without the user having to be close to it or pay attention to it. This unique property of sound has been integrated in previous designs like modern day fire alarms, sirens or smartphone notifications. Eventually, a preliminary design came into existence which ended up steering the process into the direction that evolved to be the definitive direction.

This design, which can be seen in figure 5, consisted of a simple textured panel that would be mounted on the wall at the main entrance of the house. The panel had multiple edges, which aims to invite people to drag their fingers across the panel when they walk by. The panel would then make a sound indicating a certain problem or message to the user.

PHYSICAL DESIGN

The aim in designing a panel with ridges on is to create an interaction experience that invites the inhabitants to interact with it while walking by the object. This idea originated from individual experiences in observing that people tend to intuitively drag their fingers across a ridged wall while walking past it. This intuitive and low cognition interaction idea originated from the assumption that people in 2035 will have less free time on their hands compared to today. Studies [6] have found that the amount of free time that working adults have has been dwindling for many years, and this is expected to continue. This means that people would prefer not to spend their free time checking up on the wellbeing of their house. A device that can be used while moving from place to place could be a solution to this problem.

The ridges on the panel also facilitated the opportunity to pair every ridge with a different message or space in the house, making the messages conveyed by the panel more understandable for the user.

An example of an application could be that every edge on the panel represents a space in the house, and the sound indicates whether all doors and windows are closed in that space.

The panel could also be used in a way where the direction one interacts with it from has a different meaning, which would enable the user to hear about the state of windows and doors when leaving, and about the quality of the environment in the home when entering, in which case the user will drag their fingers across the edges in the opposite direction as can be seen in the image above.



Figure 5: sketch of textured panel

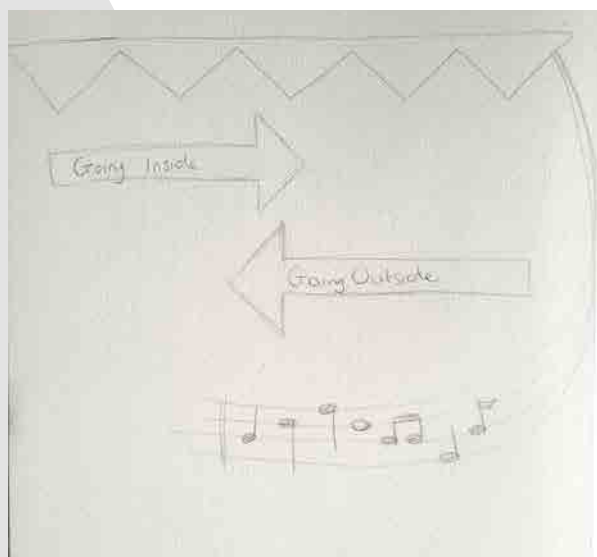


Figure 6: walking direction effect on sound

SOUND DESIGN

Along with this physical design, some early ideation was taking place on the sounds that would accompany it. The main idea for the sounds was to create a harmony that would be adjusted to intentionally break the harmony to create an odd-sounding sequence in case a situation arises. One example consisted of a scale where every ridge on the panel would have its own note, should an issue arise a corresponding note to the location would change. Alerting the user of this problem and its location at once. This design offered simplistic interactions, limiting the possibilities if offered on both sound and further interaction. Therefore, the decision was made to use the principles behind this design as a basis for new concepts instead of continuing iterations on this design. A simple interaction is not unwanted in a design project, but by looking for more fulfilling interactions a better connection to sound can be created, allowing for messages that carry denser information without making the interaction more complex.

PHASE 3: RESEARCH ON QUALITIES OF SOUND AND PSYCHOLOGY

To aid the design process, research was done on different areas that are related to our design process. This research was mostly around the usage of sound in design. Ideally, for this project the design aims to work with unique properties that sound offers. Like the fact that sound can be heard by someone who is in motion.

One of the assumptions prior to the research was that different sound properties can convey different things to people, showing that a short tone can communicate a simple message to people quicker than other mediums such as text.

THE INTUITIVENESS OF SOUND

One of the aims of using sound as an advantage in the design is to make the life of the user easier. This means that the interaction as well as the interpretation of the sound should be intuitive and not too cognitively demanding. In order to create an intuitive sound, research was done on different properties of sound and how they relate to concepts like size, distance and severity.

PITCH AND SIZE

Studies conducted on the human perception of pitch show that humans perceive pitch as a size indicator. One study [3] researched whether this perception of size is the same for everyone, regardless of culture or language spoken. The researchers studied six-month-old infants, without any prior understanding of language. Through their experiments they found that most infants indicated smaller spaces for higher pitched sounds and larger spaces for lower pitched sounds.

Based on this research, it can be concluded that the pitch of the designed sounds can show the magnitude of problems in a very quick and intuitive way, for example by playing lower pitched sounds when there is a big problem and higher pitched sounds when there is a minor problem. Furthermore, pitch could be used to indicate the size of the room the problem is coming from.

TIMBRE AND SOUND ASSOCIATION

A wide variety of research has been conducted on timbre and sound association result in an array of findings that can be applied in the design. Two general assumptions that can be made about the intuitive reaction people have to timbre are the association the user has with the sound that they hear and whether the sound is natural or not.

Experiments [8] have found that people have a safe association with sounds that one hears when engaging in a safe or soothing activity. These sounds are the same for most people but can vary depending on peoples' experiences.

Studies that are focused on the second assumption [8] have shown that sounds can be put on a scale, ranging from very organic to very industrial.

Studies have shown that organic sounds give listeners a happy and relaxed feeling, while industrial sounds have shown to bring stress and unrest. Organic materials, e.g., wooden instruments, create organic sounds. Besides organic materials, unprocessed sounds also create an organic feeling. Industrial sounds have the opposite effect and are characterized by metallic sounds, such as gears grinding. They can also be characterized by over-processed sound samples.

Insights gained from this research shows a benefit to using organic sounds when there is nothing to be alarmed of, but once the user must be alarmed, metallic or mechanical sounds can be used to create the necessary feeling of uneasy for the user to fix the problem.

PHASE 4: RE-IDEATION

WINDCHIME CONCEPT

Even though a rough direction in which to go in terms of interaction and sound was now established, the scope was still quite broad. The sounds could be used to alarm the inhabitants of many different things which made it difficult to move on and specialize the actual design. Some main topics that were being discussed were safety concerns regarding the actions of people in the house (e.g. a child is running around with a kitchen knife), safety concerns related to security (open windows or unlocked doors for example), air quality and lastly the moods of different people around the house.

When looking at the feasibility of these different areas, working on either security or air quality was most realistic as well as interesting. To then decide between these two, another look was taken at the goal of the design, which is to alarm someone using sound. The most interesting thing to do through sound is to make the invisible visible. This means that the sound is used to convey a message that a user cannot sense in any other way. As a result of this vision, the conclusion was made to focus on air quality.

Most properties of air quality cannot be sensed by people, which leaves people guessing about the quality of their in-home environment. This is dangerous since bad air quality does not only irritate the eyes, nose and throat, but can also affect the heart and cardiovascular system. The below figure illustrates the difference that a product focussing on air quality would make in a household.

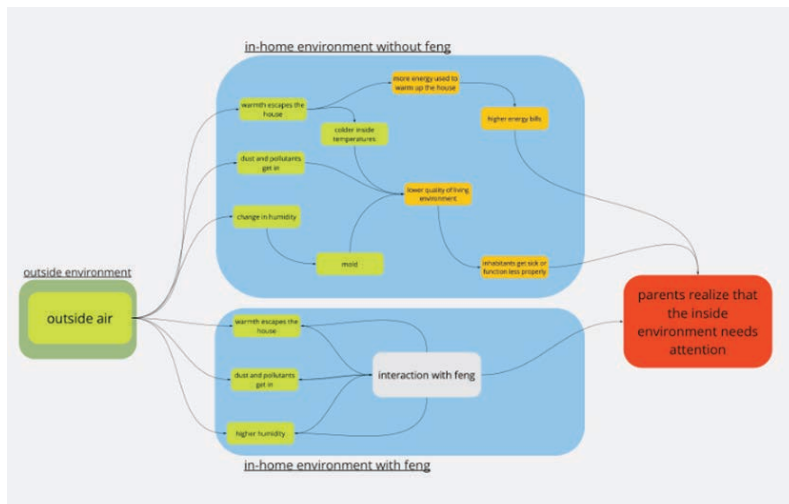


Figure 7: Relationship model of the wind chime concept

To get to a new concept with an innovative interaction, several novel approaches were taken to tackle the problem statement. One of these concerned an ideation method that we like to call 'flowchart brainstorming'. In this technique, the two main topics of interaction were placed next to each other, namely sound and air, and several qualities were tied to each of these topics. Each of these qualities then branched off in other qualities and interaction devices, and these were interconnected with matching items. This brainstorming technique served the purpose of finding a connection between the properties of sound and air that would feel natural to any user and would be easy to understand. Eventually this led to a connection visualized in figure 7, which introduces a wind chime as a medium of interaction.

As well as the design choice that led to the wind-chime inspired form, the wind chime also has a cultural meaning behind it that aligns with the function that the design performs. In ancient civilisations of Asia, people believed wind chimes attracted kind spirits while driving away evil ones, thus performing a function in the house in order to create a better in-house environment just like Feng, which drives away the evil spirit that is bad air quality.

A traditional wind chime transfers wind into motion of the pendulums, which in turn creates a sound, thus the connection of movement and sound is made. This led to the initial inspiration with the wind chime seen in the sketch in figure 8. The wind chime would be used solely as a medium to trigger a sound response of the system. By swinging the weight of the wind chime, the user would introduce motion into the system and one would expect a sound as a result of this. To visualize and test this interaction a low-fidelity prototype was created, which can be seen in figure 8. This prototype served as a form prototype, and in combination with an initial sound prototype, this served as a tool to receive formative feedback during demo day.

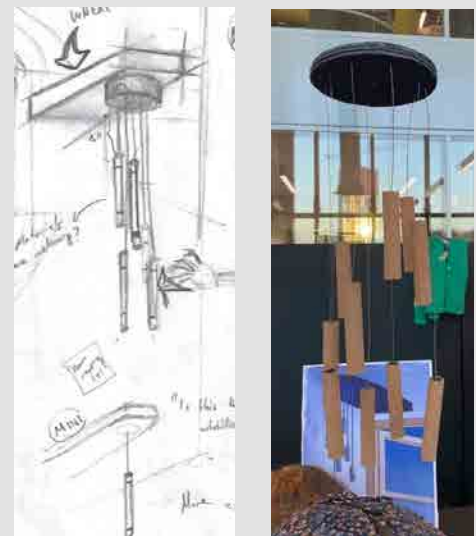


Figure 8: Sketch and prototype of windchime concept

PHASE 5: MIDTERM FEEDBACK AND DEVELOPMENT

After a solid foundation for the concept had been created, the midterm demo day was an opportunity to get some formative feedback and insights on the future of Feng. There were three fundamental areas of feedback, namely the physical location of the device inside the smart home, the interaction that needs to occur with the product to make it produce sounds, and the soundscape it would then create.

PHYSICAL LOCATION

At the beginning of the midterm demo day there wasn't a defined location for Feng yet, the only known thing determined was that the eventual place needed to be easy to access. The demo day was used as a feedback point for in which location people would see Feng being placed, with the main conclusion being either in a hallway or in the living room itself.

Talking about where Feng would be placed also sparked conversation about how the product wanted to stimulate the Zander family to go to places with potential problems around the air quality; with the main question being if interacting with an individual weight would produce sound linked to a specific room or a specific problem? This was indeed a question that wasn't fully explored, but it was found that mapping each weight to a room in the house would be the best choice since some rooms have priority for some inhabitants, and this way everyone can choose on which spaces they want to inform themselves. Of course, this does mean that each Feng would have to be custom made for every different house, with different number of rooms in the house, something that also was thought about in the digital render later in the report.

Some more feedback was given about spaces in which our service would work were regarding situations outside of the house, as some suggested also measuring the air quality in specifically the garage as the air composition has an increased risk of being bad there and is a quite different conflict that would be caused by it. Outdoor air quality was also mentioned, which could be explored in the future.

Furthermore, a point was brought up regarding what the user can do to redeem information on the air in the room they're currently in. As the concept of Feng is at the stage of demo day, in this scenario the user would have to walk to the location of Feng to check the air quality. To prevent this, each room can have one node (imagined in figure 9) to interact with for information about the room itself. This was considered outside of the scope of the project for now but should be tested in any later iterations of Feng.

INTERACTION

On the interaction a few points were brought up. The first one being, through what interaction the device was activated. The question was whether this was through motion or through touch. Sensing the motion had the benefits of allowing more freedom in the aesthetics of the device and making it easier for the user to activate multiple nodes at once.

The second point brought up was related to TomTom, the cat in the Zander family. A worry was mentioned related to TomTom, or any other pet in other homes, could be playing with the nodes and thus activating the system to the annoyance of the family. To combat this, the Feng will be placed higher up, and the nodes will only be in reach for animals when they are at their lowest position. In all instances, pets will be pets, thus the issue couldn't be fully solved in this stage of the project.

SOUNDSCAPE

The feedback related to the sounds was mostly related to them being quite literal, as it is obvious that the sound of a stream of water is a stream of water, but this could raise different associations in different users, making for an unpredictable system. Therefore, it was advised to take another look at the sounds and see if they could be altered to become more subtle. That being said, mapping complexity of sound to the size of the problem is more interesting than volume or pitch; as there is no distinguishable baseline volume it is more difficult to gauge the relative urgency, while the sound of a dripping tap vs a stream of water has more obvious correlations.

Furthermore, it was brought up where the sounds would be coming from, and whether this won't be disturbing for other inhabitants of the home. To battle this, Feng will use an assumed home-wide directional speaker system of the room it is placed in to convey the location of the problem. It will use the directional properties of sound, through calibrating the speakers of the room, to indicate location. The fact that the input and output is not all handled by the device itself, does mean that it will be harder for a human to combine these aspects in their head, but by having no latency between the action and reaction, the Feng functions in essence as an instrument or a Midi-controller, playing sounds in line with each trigger coming from the interaction.

Combined, this feedback allowed for some minor changes in the final concept which is described in the next phase of this report. Some of the feedback was reserved for later stages of the project and is described in the final phase, due to it not being manageable to apply or solve all feedback points within the timeframe of this project.

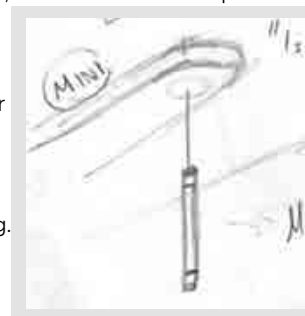


Figure 9: Sketch of singular Feng node

PHASE 6: CONCEPT FREEZE

By implementing some of the feedback received from the midterm demo day, the earlier wind chime concept was altered while further feedback was reserved for a later iteration of the design. This led to the final iteration of Feng, a conceptual system meant to sonify the air quality of the house. The system gets its name from the Chinese-mandarin word for wind, hinting at the qualities it's meant to sonify while respecting the traditionally Chinese inspiration. The device is shaped like a wind chime, with each of its pendulums corresponding to one room of house. These pendulums (nodes) move up and down, their upmost position indicates that there is not an issue, and as the pendulums get lower in height compared to their resting position, it signals that there has been an update concerning that room of the house. This up-down motion aims to catch the eye of someone passing by, inviting them to interact with the node. By swinging, hitting or in any other way introducing motion to these pendulums, the systems' sound feature is activated. Feng is meant to raise awareness of problems and not offer solutions to them; this allows the inhabitants of the home to maintain control over the air quality of their house as well as gaining an educated understanding of the body language of their home.

SOUND

The designed sounds take inspiration from nature itself. Feng aims for an emphasis on re-connecting with nature. The sounds triggered are formed out of two main parts. A main tone which has been adapted from a wind chime recording, and a contextual undertone which has been adapted from recorded events in nature. The undertones change from context to context and can be overlapped. The different dimensions and variables determining how a "trigger" is sonified are the direness of the situation and the existence of undertones as it can be seen from figure 10. Depending on these undertones, the MIDI sequence changes. With the situation being more complex, the main tone also gets triggered multiple times with multiple pitches, while also triggering the undertone(s) associated with the event being played.

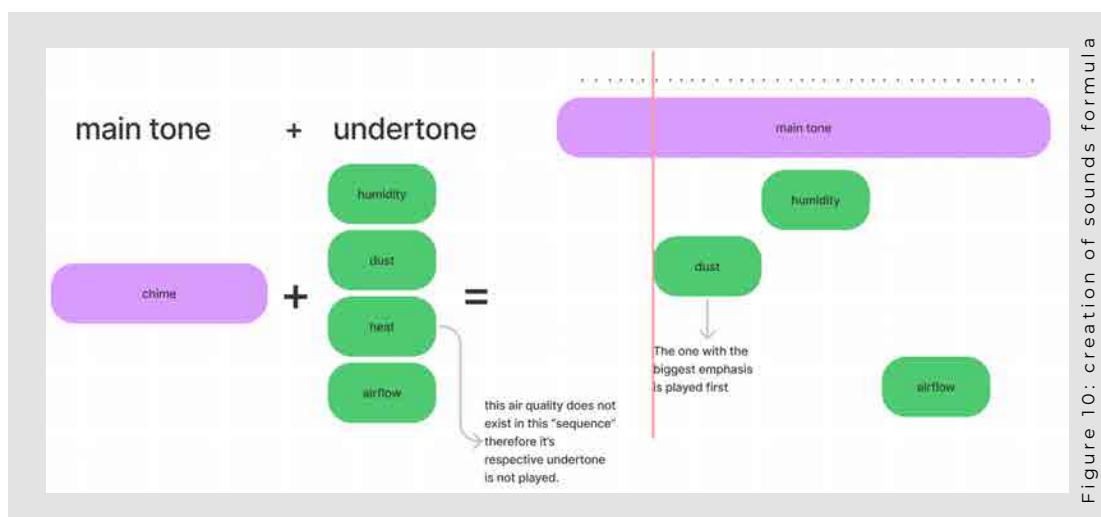


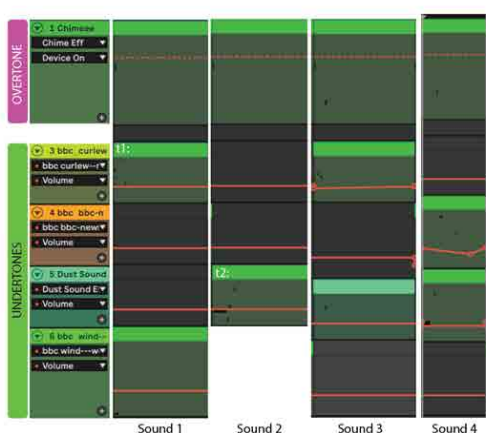
Figure 10: creation of sounds formula

The sounds have been modified and adjusted utilizing Ableton. To test four determined qualities of air, four different "undertones" were designed as different instruments. To avoid being too obtrusive and obvious, samples from common natural events were altered to be simpler, while still holding their familiar auditory qualities.

The pitch of the main tone (chime) changes depending on how dire the situation demonstrated is and therefore is also related to the height of the chimes. This quality has been determined by using research that has been noted in page 5.

The four "undertones" model the following qualities of air; humidity, temperature, contamination (dust) and airflow. Depending on the magnitude of "existence" of an undertone, the volume of the undertones in the overall tone is changed, as it can be seen from the red lines from figure 11, the changes in the undertones make the soundscape seem more alarming, this is again based on previous research. In Appendix B, the process of creating the undertones through filters and effect can be found.

To test the system several prototypes were created. The first iteration was a purely aesthetic prototype that was used on the midterm demo day, to test the understanding of the concept and allow for a discussion topic. This concept prototype which has been described under Phase 4 served as a starting point for a more elaborate prototype. The second interaction prototype created was a functional device. After the concept freeze, realization of the concept began in a multitude of platforms, these being a physical prototype, a materials study, a form exploration and a digital prototype in the form of a render.



Close Up of the Midi Composition



Figure 11: midi instrument setup for sounds

PHASE 7: REALIZATION

FORM EXPLORATION

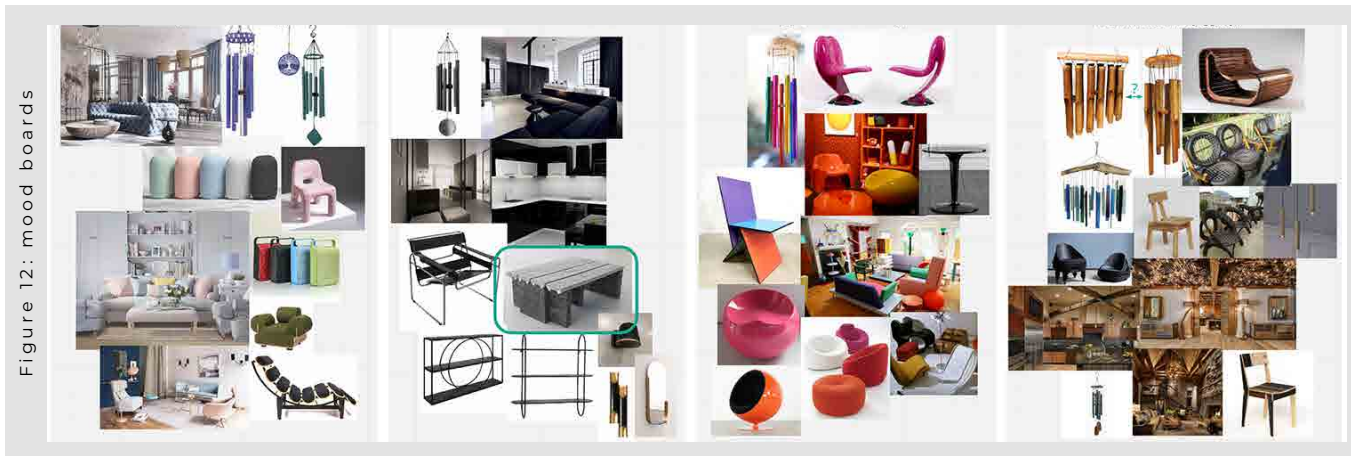
Feng is designed for a house in the future, and with the rapidly changing style of interior design, a lot of speculation is involved in deciding future design trends. A product can often be dated by just the way it looks, but Feng is supposed to be a part of the house that collaborates with the inhabitants the same way whether it is a single year or two decades old, therefore it is essential to create a timeless look that won't quickly be outdated.

To find and create such aesthetics, an exploration was conducted through identifying design languages that are in style at the moment, or convey a certain modernism despite their age. By searching the internet and finding similar interiors, furniture or other products and dividing these into categories, four different mood boards (see figure 12) were created that each represented a major facet of the broad design spectrum.

These categories were as follows:

- Soft-looking products that are constructions made up from slightly rounded or stretched out geometric shapes, covered in matte finishes of pastel, or otherwise light and easy on the eyes, colors; complemented using light wooden accents.
- Minimalistic design where everything consists of sharp, bold, linear forms in the black-white-grey spectrum, smooth and even surfaces, sparsely broken up by a primary accent color or metal edging.
- 70's-inspired interior that is not bound by rules on form, these shapes are tinted in primary and secondary colors, eye catching designs that still maintain sleek impression through glossy finishes and flowing surfaces.
- Rustic, misaligned, surfaces broken up by variations in texture or color, colors that reflect the natural properties of the used materials. Wood, leather, rubber and brass accents get implemented frequently, creating space for often repurposing and recycling.

It was decided to continue development with the minimalistic, grey-scale genre, as this came across as the most versatile and neutral style that would fit in almost every interior. It was also seen as the most future proof, being able to trace the reoccurrence of sharp geometric shapes in all human progression.

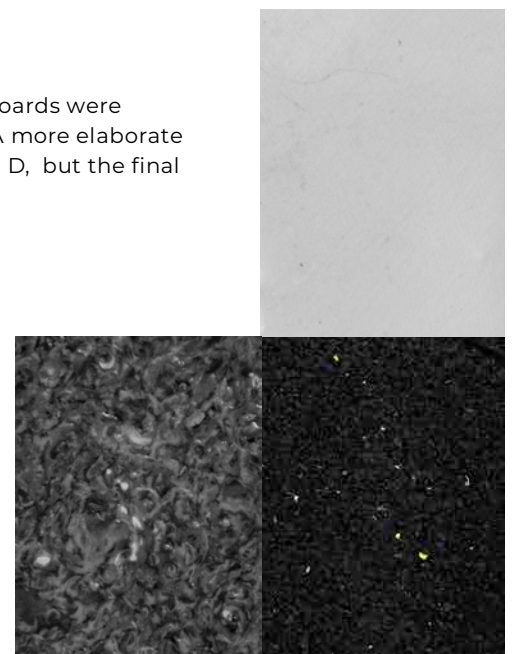


MATERIAL IDEATION

Having the themes as a foundation for picking the colors of Feng, the digital mood boards were transformed into physical ones by sourcing materials that fit each of these categories. A more elaborate description about the interaction with and research on these can be found in Appendix D, but the final choices of the materials to go along with this form is shown in figure 13.

Plastic, rubber and aluminum were picked, partly as they can all be taken from recycled sources, making these important picks in a sustainability-oriented perspective. The materials also have desired properties for this use scenario, such as rubber being able to dampen the impact of the nodes against each other and thus reducing noise; and a combination of plastic and metal for the body, creating a structure that is both strong and light weight.

The eventual manufacturing of Feng in full scale is also important for a viable concept. Like previously stated, recycled materials will be used, but purely black plastic is difficult to recycle [2], which is why grayscale colors were chosen instead. In the materials samples, PE plastic was used for its low melting point, but PP or ABS could also be used as it is widely available and offers better scratch resistance, which is preferable over the nicer tactile feeling of PE for the longevity of the device.



PHYSICAL PROTOTYPE

The aim in the physical interaction prototype is to aid the user test with a physical object that is as close as possible to the visual design in the render. The prototype has four functional nodes that have vibration sensors inside. These nodes need to move up and down to simulate the designed functionality of showing that there has been an update and conveying urgency.

To achieve this effect, a mechanism was designed in Fusion360. This mechanism consisted of one servo motor, one 3D printed pulley, one 3D printed mounting arm for the servo and one counter support arm (also 3D printed) to act as a fulcrum. These pieces attached together made a simple lifting mechanism for the Nodes (figure 14).

The overall enclosure needed to be large enough to fit four of these mechanisms and still be similar to the proportions in the virtual prototype. The circular baseplate which the pulley mechanisms are installed on has been laser cut from a MDF piece. Because the entire prototype has been modelled in fusion 360 (figure 15), the dimensions and cuts needed to be made were easy and straightforward.

One challenge in building the physical prototype was the wires and routing. Because the wires serve the purpose of both carrying data from the nodes to the Arduino and being the weight carrying support for the nodes, they had to be thick. Four of the "nodes" had SW-420 Vibration sensors inside them. These sensors were chosen as they were low cost, easy to install and easy to work within code. For each sensor, a corresponding SG90 Servo was installed to generate the height difference wanted from the nodes to demonstrate a situation update. All these components are controlled by an Arduino nano. The code snippets attached in Appendix E give an insight into how the code talks to another piece of code within processing. When motion is detected by the SW-420 sensor, a corresponding sound demo is played through the speakers of the connected laptop. This allowed for a close to real-life setting, which was perfect for the user testing performed in the next phase.

Each node is formed out of slices of laser cut MDF being glued together. Special cutouts were made to hold vibration sensors inside. In the next iteration, this material choice should be altered as it turned out to be more fragile and imprecise than expected. Later, the enclosure was assembled utilizing laser-cut MDF sheets and 3D-printed structural parts. The physical unit seen in figure 13 was then complete with the addition of a mounting mechanism to use while user testing the prototype.

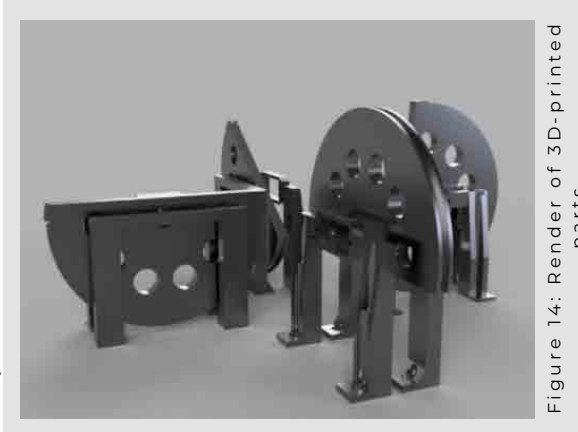


Figure 14: Render of 3D-printed parts



Figure 13: Final prototype of Feng

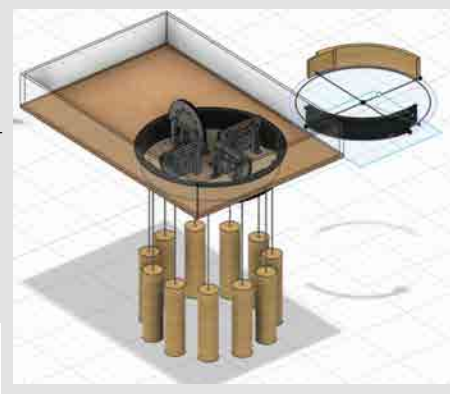


Figure 15: Fusion360 model of Feng

RENDER

Considering the design is meant to exist in 2035, it is natural that the prototype created in the present does not represent what Feng would look like 14 years from now. In order to properly convey the way Feng would look like in 2035, a computer render was created using Blender, which can be seen in figure 16.

Whilst the computer render looks similar to the prototype in form, it is also quite different in a number of ways. Firstly, the materials in the render are directly used from the sample materials sourced during the realization phase of this project. These materials are sustainable and are suspected to be more prevalent in 2035 considering the use of sustainable materials are a way of combatting climate change [7]

Additionally, the design is thinner and features sharp modern edges as well as more organic circular shapes. One important detail that the render features is the circular slot that the wires and pendulums are suspended from. One point of feedback at the demo day was targeted at the fact that there is a pendulum for every space in the house, which means that Feng had to be customizable depending on the home it was going to be installed in. Feng was made customizable by adding a circular slot that the pendulums could be slid into. This way, pendulums can be added and evenly distributed across the entire circular slot, creating more possibility for adding or removing pendulums while keeping it neat and organised.



Figure 16: Render of Feng

PHASE 8: USER TESTING

USER TESTING

Using an extensive user testing protocol, strong and weak points in any design can be identified and improvement points for the design can be established. Thus, by conducting a user test for the proposed co, testing the proposed Feng concept, areas for improvement were searched for a future iteration of the concept.

Within the user test two main points will be tested, namely:

- The intuitiveness of interaction
- The distinguishability and intuitiveness of the sounds

To be able to determine these, both quantitative and qualitative research was performed. The participants in the research first discovered the functional prototype and were then asked to fill in a Subjective Mental Effort Questionnaire (SMEQ) in combination with a User Evaluation Questionnaire (UEQ). This was followed by a semi-structured interview, meant to shine more light on the opinions expressed in these questionnaires and to provide more in-depth feedback on the Feng concept. In the following text, both the quantitative and qualitative methods are discussed in combination with an analysis of their results. The test protocol used for this user test can be found in Appendix F.1.

QUANTITATIVE STUDY

For the quantitative methods, only seven results were filled against the expectations of having more. This means that due to significance the results cannot be taken as representative. However, they are still seen as formative feedback for future iterations of the design and will thus be discussed as such.

As mentioned before, two quantitative measures were used. Firstly, a cognitive load assessment was performed in the form of a SMEQ. A cognitive load assessment is a tool used to determine the amount of working memory resources to utilize a product or service [1]. The SMEQ consists of a straight line with nine labels ranging from 'Not at all hard to do' to 'Tremendously hard to do', it is performed by asking the participant to indicate where on this scale their experience lays through a straight line through this vertical scale. By measuring the number of millimeters from the start of the scale to the indication by the participant, this method produces a single quantitative measure per participant. A table containing these values and the aggregated data for all participants can be found in Appendix F.2. With an average of 38.6 and a standard deviation of 27.5, the results show a fair cognitive load, as can easily be seen in the boxplot shown in figure 17. The cognitive load varies within the boundaries of 'Not hard to do' and 'Rather hard to do', where the average is indicating a value of 'Fairly hard to do'.

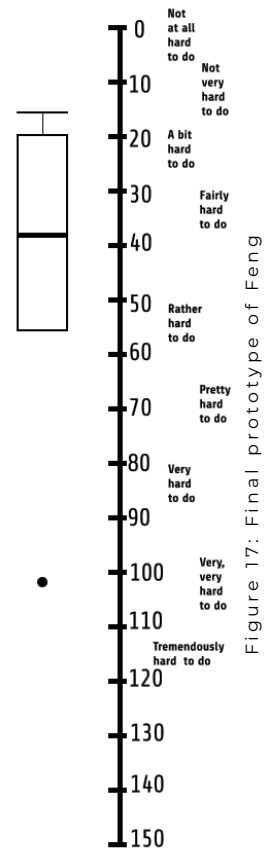


Figure 17: Final prototype of Feng

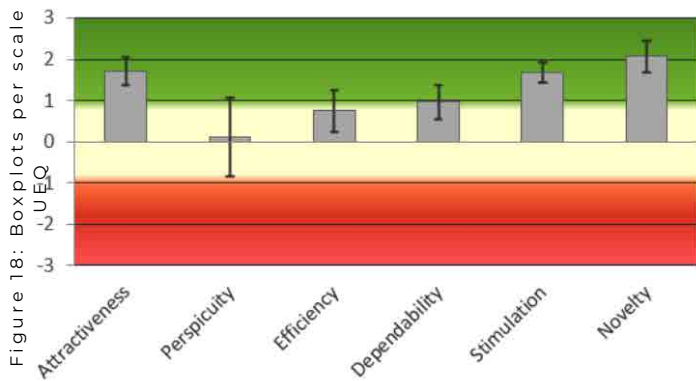


Figure 18: Boxplots per scale

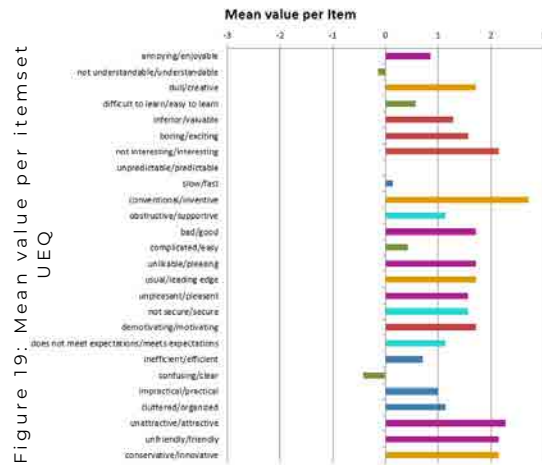


Figure 19: Mean value per itemset

Secondly, a UEQ was filled in by the users. The UEQ is a standardized questionnaire to determine the user experience of a product or service [1]. The questionnaire consists of 26 opposing item sets and the participant is asked to rate their experience through a 7-point Likert scale between these two item sets. These 26 item sets can be divided into six scales, all representing different values that a product or services' user experience could be improved on.

In figure 19 the mean value per item set can be found, with the colors representing the scale which this item set belong to. Figure 18 displays 6 boxplots, each one representing one of the 6 scales the item sets can be subdivided in. The results show that Feng scores quite well on Attractiveness, Stimulation, and Novelty, which indicated that the project is attractive to use, exciting and motivating to use, and is innovative and creative. However, results on perspicuity, or how easy to use the product/service is, are very divided. Both the scales of dependability and efficiency score relatively neutral results.

QUALITATIVE STUDY

Gathering qualitative data was an important means of gaining an insight into the way potential users interpret and interact with the design. Gaining insight into the way the product is being interacted with indicates what could be altered in order to make the experience more intuitive and cognitively more manageable.

The target population for these qualitative evaluations consist of anyone that could be a potential user of the design. This excludes experts on the area of sound design since they are better trained at hearing different sounds and therefore produce invalid test results. Another group of people that is to be excluded from the evaluations is people with hearing impairments that disable them from hearing the sounds made by the design, which will again produce invalid results, since they cannot process the information supplied to them by the design.

In order to perform the qualitative evaluations described below, the only equipment and logistics needed were the prototype and sound speaker as well as a list of precomposed questions that are to be used in a semi-structured interview. Furthermore, these tests are ethically approved by the Ethical Review Board of the TU/e and will be conducted after signing a consent form approved by the project coach.

The qualitative part of the study consists of observing the participant while they interact with the design after receiving little explanation about what the design does. The participant is asked to think aloud, these thoughts are then noted down to allow analysis. During this interaction, 4 scenarios are cycled through. Each of them has the nodes hanging at different heights and display different sounds. This allows the participant to experience Feng in different scenarios to create a better image of its functionality. After the participant interacts with the design, a semi-structured interview takes place.

To analyze the qualitative data that was collected during the observation and the interview, the observations and the interview had to be transcribed. Within the transcription, any useful comment on the design could then be marked and grouped using distinct color codes. Composing these different groups while going through the results was already an indicator on areas of improvement or merit. Grouping the different statements made by the participants offered extra insight into what exactly could be improved upon.

These color codes indicated feedback on intuitiveness, sound and design as main categories, differentiations were also created between sub-categories. The code used, and the transcribed interviews and observations can be found in Appendix F.3 and F.4. To offer a clear overview of the results a visual representation of the results was made through a diagram shown in figure 20. In these visualizations, the most common feedback is included. Other feedback points can be found in the transcribed data in appendix F.4.

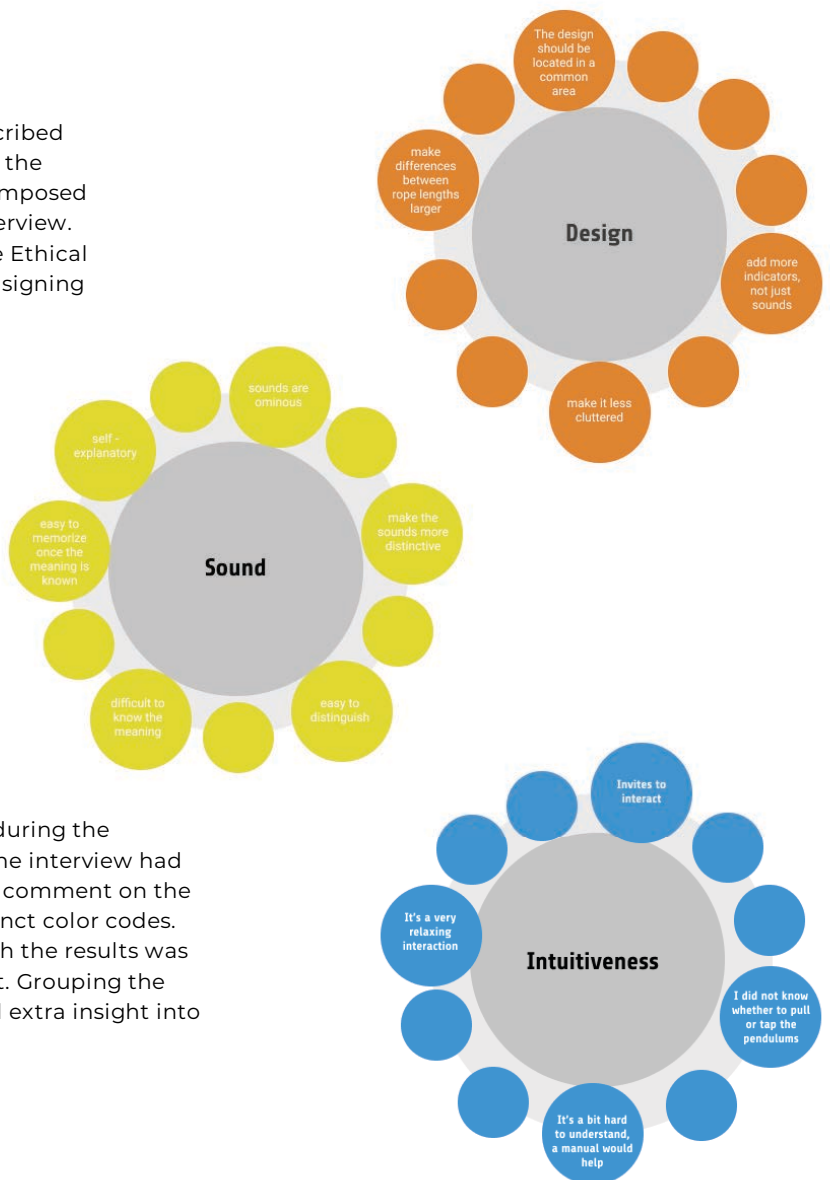


Figure 20: Visualizations result user interviews

PHASE 9: CONCLUSION/FUTURE STEPS

If the product were to ever hit the market, more iterations would have to be done. Based on the results of the last user testing phase, some future steps have been thought of. These future steps are meant to improve the user experience as well as reduce the cognitive load of using Feng and are focused on the physical design along with the sounds.

In terms of Sound, based on the feedback received through the user tests, the conclusion is to make the sounds more distinct and to increase the emphasis on the undertones, making them clearer. This can be managed by changing the volume levels of the main tone and the undertone. Furthermore, a cut-off of the main tone could be added, while the undertone is getting triggered. On top of these improvements, emergent functionality could be added to the sounds to include more events as the device gets adjusted to one's home and reactions to different situations. Considering the environment this device is placed in, it is possible to assume that an AI (Artificial Intelligence) element is present in the house, generating new undertones for different situations that have been detected by household sensors. This way the device would diverge the knowledge it can convey and come closer to reaching its main target, which is to make the inhabitants aware of the air quality.

For the physical part of the design, the user tests also indicated a few changes that could be implemented in the future. For instance, some participants found it confusing that there was no clear sign that Feng was powered on or ready to be interacted with. Additionally, many different participants suggested adding other ways of communication other than just sound, such as light. These findings led to the possibility of adding lights to Feng in a further stage, to communicate whether the device is powered on or not as well as how high the need for interaction is.

Furthermore, a future step would be to add a simple singular controller to every space in the house. This would perform the same function as Feng, but only for that room. It would enable someone to tap into the air quality of the room they are in without having to walk back to the central space where Feng is positioned.

One final future step that the user tests indicated could be useful was the creation of a user manual. In the results of the user experience questionnaire, one can see only two prompts that are skewed towards the negative side of the spectrum. Both of these prompts are related to the understandability of the product and the confusion in causes. When asking the participants about it in the interview, they indicated that a more detailed explanation would have minimized the confusion they experienced while interacting with the device. The participants that were confused by the design also indicated that a user manual would be helpful in supplying them with that desired explanation in case they were to ever purchase Feng.

DISCUSSION

During a design process, learning opportunities always present themselves; whether these are things that didn't go the way they should, could have been conducted more efficiently or just went different than expected in a positive way, there are always ways to tweak your perspective.

The first of these reflection points emerged in the first phase of the project where there were ideas being generated, yet they weren't explorative enough: The initial ideas were already being scrutinized to such a detailed level it took the flow out of testing different things and thus had the group getting stuck on concepts quickly. At the same, a lack of preparation on the subject, such as not explicitly defining a 'smart device' was the cause of further delay.

A further drawback of this detail-oriented, yet overly intuitive mindset is that the big picture of the project was sometimes lost, causing emergent technologies to be less embraced than desired. A positive counterbalance is that a well-timed implementation of the work ethic does result in a very-well discussed concept, making for a simple solution to the problems faced, creating a roadmap at the start of the process. This ensures that the project's topic and timetable are analyzed, as well as that the exploration and deepening of concepts happen at times when it is relevant.

Something that went quite well in the project was the simultaneous ideation of both the material-selection and work on the functional prototype of Feng. As Feng has a geometric design, fabricating a big prototype out of the final materials would not be much different than creating the small rectangular samples, but only require more work, money and time that could be spent somewhere else in the project. Laser cutting and 3D printing allowed for quicker ideation, making part of the team able to fix mistakes if parts didn't turn out perfect, while others could spend additional time expanding material research that otherwise had to be finished already. The prototype lacked aesthetic fidelity, but a render made up for this missing physical visualization. Properly distributing tasks and gauging two processes can happen at the same time can greatly increase efficiency in any project.

The previously described Future Steps were mainly concluded from the findings of the user studies, which means the protocol had been compiled well to result in useful feedback; yet the number of studies conducted does inhibit trusting these conclusions fully. Generating the user-setup is the main effort of user-studies, and to get the most out of this time-investment, it is as simple as just conducting more studies, and to allow for this the implementation of a roadmap and time-schedule of the project once again proves useful as more actions can be anticipated and scheduled in between deadlines.

Ticking the box on all Expertise Areas that form the core of Industrial Design is essential for the development of a complete designer, and while most of these topics have been thoroughly explored -like Creativity & Aesthetics through designing the form of the device, Technology & Realization by the creation of a functioning prototype and researching final materials, and User & Society and Math, Data & Computing where tackled in the conducting and analyzing of User Studies – one of these was lacking, Business & Entrepreneurship; this was a topic that was always present at the back of our minds during discussions as market-viability was often a motivator for quick decisions, these influences should be more explicit in the final product and report; this could be achieved by identifying stakeholders and approaching real companies to underpin certain perspectives, which was tricky due to the futuristic subject-matter of the squad; yet many existing businesses have elaborate future directions that could have been looked at.

As said before, there are always things to be learned from and improved upon, and while this certainly is the case, it is also important to close off endeavors to be able to utilize this new knowledge on new projects.

CONCLUSION

The aim of this project as stated in the introduction was to 'Design an interactive system that allows for communication of the air quality within the home through its soundscape'. The design called Feng that is presented throughout this report is in fact an interactive system that puts the inhabitants of the house in contact with the air quality inside of their house. By communicating the air quality in the house with the inhabitants, it makes the invisible visible.

Not only have user tests shown that the final design of Feng invites the interaction of swinging the pendulums. Furthermore, they have also concluded that the fluctuation of the weights of the pendulums invites further interaction when it is most needed. The sounds have been found to be distinguishable and with the right amendments they could easily be interpreted as well. Just like any design, Feng is not perfect and can be improved upon, as has been discussed in the 'future steps' part of the report, but altogether, despite drawbacks and valuable teaching moments, the aim of the project was achieved. Feng works how it was designed to work and is therefore expected to help users improve the air quality inside their houses.

The project can be useful for anyone who wants to get inspiration on design paired with sound and how it can create a better relationship between people and their environment.

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APPENDIX A - INITIAL SKETCHES

A FIGURE SHOWCASING SKETCHES THAT REFLECT THE FIVE DIFFERENT ASPECTS OF THE FIRST PHASE, EACH COLOR CONNECTING TO A DISTINCT EXPLORATION DESCRIBED IN THE REPORT



APPENDIX B - SOUND

THE INSTRUMENT SETTINGS FOR THE OVERTONE (THE CHIME)

The screenshot shows the software interface for the 'Chimeee' instrument. The top section displays a waveform with a highlighted loop region from 0:34 to 0:36. Below the waveform, the 'Sample' settings are: Reverse (Off), Sample (95754 3bagbrew bai), Vol (0.0 dB), Sample Start (1478240), Sustain Mode (Link), Loop Start (1593697), Loop End (1625937), Crossfade (0), Detune (0 ct), and Interpol (Norm). The 'Filter/Global' settings include Snap (Off), Root (C3), Detune (0 ct), Scale (100%), Pan (C), Sample End (1625937), Release Mode (OFF), Release Loop (0), Crossfade (0), and Detune (0 ct). The 'Filter' section shows a low-pass filter with a frequency of 22.0 kHz and a resonance of 0.0%. The 'F.Env' section shows an envelope with an initial level of 0.0%, a peak of 100%, and a sustain of 0.0%. The 'Volume' section shows a volume of 0.26 dB and a velocity-to-volume curve. The 'Chime Eff' section shows a carrier of 'Enhanced' and a depth of 99.2%.

FOR THE HUMIDITY UNDERTONE

The screenshot shows the software interface for the 'bbc curlw--nu nhu0502802' instrument. The top section displays a waveform with a highlighted loop region from 0:11 to 0:13. Below the waveform, the 'Sample' settings are: Reverse (Off), Sample (bbc curlw--nu nhu0502802), Vol (2.7 dB), Sample Start (516622), Sustain Mode (Link), Loop Start (550401), Loop End (607758), Crossfade (0), Detune (0 ct), and Interpol (Norm). The 'Filter/Global' settings include Snap (Off), Root (C-1), Detune (0 ct), Scale (100%), Pan (11R), Sample End (611998), Release Mode (OFF), Release Loop (0), Crossfade (0), and Detune (0 ct). The 'Filter' section shows a low-pass filter with a frequency of 10.0 kHz and a resonance of 0.0%. The 'F.Env' section shows an envelope with an initial level of 0.0%, a peak of 90%, and a sustain of 100%. The 'Volume' section shows a volume of 30.5 dB and a velocity-to-volume curve. The 'Chime Eff' section shows a carrier of 'Enhanced' and a depth of 99.2%.

FOR THE HEAT UNDERTONE

The screenshot shows the software interface for the 'bbc bbc-news-s 0009040' instrument. The top section displays a waveform with a highlighted loop region from 0:12 to 0:14. Below the waveform, the 'Sample' settings are: Reverse (Off), Sample (bbc bbc-news-s 0009040), Vol (4.9 dB), Sample Start (461164), Sustain Mode (Link), Loop Start (566267), Loop End (759313), Crossfade (0), Detune (0 ct), and Interpol (Norm). The 'Filter/Global' settings include Snap (Off), Root (C1), Detune (0 ct), Scale (100%), Pan (C), Sample End (759313), Release Mode (OFF), Release Loop (0), Crossfade (0), and Detune (0 ct). The 'Filter' section shows a low-pass filter with a frequency of 10.0 kHz and a resonance of 0.0%. The 'F.Env' section shows an envelope with an initial level of 0.0%, a peak of 90%, and a sustain of 100%. The 'Volume' section shows a volume of 30.5 dB and a velocity-to-volume curve. The 'Chime Eff' section shows a carrier of 'Enhanced' and a depth of 99.2%.

FURTHER INTERACTIVE EXPERIMENTATION WITH SOUND:

**SOUNDBOARD DEMO SOFTWARE (PROCESSING
SKETCH) DOWNLOAD LINK**

<https://mega.nz/folder/AhIWIZJK#YnMHeybEJgeWQNUeaJtNbg>

ABLETON PROJECT DOWNLOAD LINK:

https://mega.nz/file/Yp9SALxa#KKxU4aIrwujPxBpG78Pi0AuD1mZwyO_-ZDdXIOE7Wj0

APPENDIX C - REFERENCES TO MOODBOARDS

HERE ARE ALL LINKS LISTED, TAKING YOU TO WEBPAGES THE IMAGES USED IN THE MOOD BOARDS WERE SOURCED FROM. A DISCLAIMER: THESE COLLAGES WERE FINISHED ON THE 7TH OF DECEMBER, MEANING THAT PHOTOGRAPHS COULD HAVE BEEN ALTERED OR PRODUCTS MIGHT HAVE SOLD OUT AFTER THE FINALIZATION OF THIS REPORT.

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70'S INSPIRED

VINTAGE ABSTRACT DESIGN [HTTPS://SOCIETY6.COM/PRODUCT/COLORFUL-RETRO-STRIPES-70S-80S-ABSTRACT-DESIGN1219694_POSTER](https://society6.com/product/colorful-retro-stripes-70s-80s-abstract-design1219694_poster)
GEOMETRIC COLORFUL CHAIR [HTTPS://BESTWELHIP.NL/VINTAGE-DESIGN-VILBERT-CHAIR-STOEL-VERNER-PANTON-IKEA/](https://bestwelhip.nl/vintage-design-vilbert-chair-stoel-verner-panton-ikea/)
MEMPHIS GROUP INTERIOR [HTTPS://NL.WIKIPEDIA.ORG/WIKI/BESTAND:MEMPHIS-MILANO_MOVEMENT.JPG](https://nl.wikipedia.org/wiki/Bestand:Memphis-Milano_Movement.jpg)
GREEN 70'S PATTERN [HTTPS://WWW.PINTEREST.CO.UK/PIN/207587864046455366/](https://www.pinterest.co.uk/pin/207587864046455366/)
ORANGE ROUND CHAIR [HTTPS://WWW.1STDIBS.COM/DESIGNS/EERO-AARNIO-BALL-CHAIR/](https://www.1stdibs.com/designs/eero-aarnio-ball-chair/)
COLLECTION VINTAGE CHAIRS [HTTPS://NL.PINTEREST.COM/PIN/731694270718985729/](https://nl.pinterest.com/pin/731694270718985729/)
FLOWING COLORS ILLUSTRATION [HTTPS://WWW.BEHANCE.NET/GALLERY/60611959/BOOGIE-NIGHTS?](https://www.behance.net/gallery/60611959/Boogie-Nights?tracking_source=project_owner_other_projects)
[TRACKING_SOURCE=PROJECT_OWNER_OTHER_PROJECTS](#)
FINN STONE BALL CHAIR [HTTPS://NL.ALIEXPRESS.COM/ITEM/2021767295.HTML](https://nl.aliexpress.com/item/2021767295.html)
COLLECTION FABRIC CHAIRS [HTTPS://WWW.MISTERDESIGN.NL/LIGNE-ROSET-PUMPKIN-POEF.HTML](https://www.misterdesign.nl/ligne-roset-pumpkin-poef.html)
TONGUE CHAIR [HTTPS://DECORATRIX.COM/LAS-SILLAS-LENGUA-EN-LA-MEJILLA](https://decoratrix.com/las-sillas-lengua-en-la-mejilla)
ORANGE INTERIOR [HTTPS://ERAMUSU.COM/ES/ERASMUS-BRUSELAS/QUE-VER/ORANGE-DREAMS-PLASTIC-IS-FANTASTIC-3361](https://eramusu.com/es/erasmus-bruselas/que-ver/orange-dreams-plastic-is-fantastic-3361)
RAINBOW WINDCHIME [HTTPS://WWW.AMAZON.COM/BREEZE-RAINBOW-WIND-CHIME-48-INCH/DP/B00OCNO3CM?TH=1](https://www.amazon.com/Breeze-Rainbow-Wind-Chime-48-Inch/DP/B00OCNO3CM?th=1)
BLACK SHINY TABLE [HTTPS://MINO-FURNITURE.COM/MATTE-SHINY-BLACK-ACRYLIC-ROUND-SIDE-TABLE/](https://mino-furniture.com/matte-shiny-black-acrylic-round-side-table/)
COLORFUL SWIRL PATTERN [HTTPS://NL.PINTEREST.COM/PIN/556053885247459467/](https://nl.pinterest.com/pin/556053885247459467/)

SOFT DESIGN

PASTEL BLUE INTERIOR [HTTPS://WWW.ARCHITECTUREARTDESIGNS.COM/16-BEAUTIFUL-PASTEL-INTERIOR-DESIGN-IDEAS/](https://www.architectureartdesigns.com/16-beautiful-pastel-interior-design-ideas/)
GOOGLE NEST SPEAKERS [HTTPS://BLOG.GOOGLE/PRODUCTS/GOOGLE-NEST/NEW-NEST-AUDIO/](https://blog.google/products/google-nest/new-nest-audio/)
PINK RECYCLED CHAIR [HTTPS://WWW.REWINDDESIGN.BE/COLLECTIONS/ECOBIRDY/PRODUCTS/CHAIR-CHARLIE-STRAWBERRY](https://www.rewinddesign.be/collections/ecobirdy/products/chair-charlie-strawberry)
VIZLINE STUDIO INTERIOR [HTTPS://WWW.BEHANCE.NET/GALLERY/56069087/APARTMENT-PROJECT-TRUBETSKAYA](https://www.behance.net/gallery/56069087/Apartment-Project-Trubetskaya)
PASTEL PHONE CASES [HTTPS://WWW.ITSLAUT.COM/PRODUCTS/HUEX-PASTELS-FOR-IPHONE-SE-2020](https://www.itslaut.com/products/huex-pastels-for-iphone-se-2020)
GREEN GEOMETRIC CHAIR [HTTPS://WWW.SPECTRUMDESIGN.NL/COLLECTIE/MVPHE-FAUTEUIL/](https://www.spectrumdesign.nl/collectie/mvphe-fauteuil/)
PASTEL RAINBOW INTERIOR [HTTPS://DESIGN-MILK.COM/10-MODERN-ROOMS-PASTEL-ACCENTS/](https://design-milk.com/10-modern-rooms-pastel-accents/)
BLUE WIND CHIME [BUY WIND CHIMES THAT ARE FRIENDLY TO NEIGHBORS 29 SOFT AND HARMONIOUS MELODY & ALUMINUM CHIMES MADE OF BAKING PINT GREAT GIFT OR TO KEEP FOR YOUR OWN PATIO, PORCH, GARDEN, OR BACKYARD ONLINE IN TURKEY. B098DSJ6R9 \(UBUY.COM.TR\)](#)
GREEN WIND CHIME [PREMIUM WIND CHIMES-6 HOLLOW ALUMINUM TUBES 28" WIND CHIME FOR GARDEN,YARD,PATIO AND HOME DECORATION \(GREEN\) | WALMART CANADA](#)
SQUARISH SPEAKERS [HTTP://WWW.SOFTY.CO.IN/CABLES.HTML](http://www.softy.co.in/cables.html)
PINK BOWL AND TAP [HTTPS://WWW.BOL.COM/NL/NL/P/WASKOM-ROND-VICTORIA-COLOR-LINE-PASTEL-ROZE-INCL-WASTE-OP-KLEUR/9300000005873787?BLTGH=TL5H8Y-Q0SNKZRXX-M1KCG.2.17.19.PRODUCTIMAGE](https://www.bol.com/nl/nl/p/waskom-rond-victoria-color-line-pastel-roze-incl-waste-op-kleur/9300000005873787?BLTGH=TL5H8Y-Q0SNKZRXX-M1KCG.2.17.19.PRODUCTIMAGE)
PASTEL FRAMED ARTWORK [HTTPS://WWW.ETSY.COM/NL/LISTING/262015568/GROTE-MINIMALE-MODERNE-KUNST-KWEKERIJ?CLICK_KEY=0C864C22B2A5AB80E3494C4F0DBD8920883FBC9B9%3A262015568&CLICK_SUM=D07A3834&REF=SHOP_HOME_RECS_12](https://www.etsy.com/nl/listing/262015568/grote-minimale-moderne-kunst-kwekerij?click_key=0c864c22b2a5ab80e3494c4f0dbd8920883fbc9b9%3A262015568&click_sum=d07a3834&ref=shop_home_recs_12)
PINK WIND CHIME [HTTPS://WWW.ALLAMERICANSTORE.US/FOR-THE-GIRLS-47-INCH-PINK-WIND-CHIMES/](https://www.allamericanstore.us/for-the-girls-47-inch-pink-wind-chimes/)
ABSTRACT WALLPAPER [HTTPS://WWW.RAWPIXEL.COM/IMAGE/1218228/COLORFUL-CAMOUFLAGE-PATTERNED-BACKGROUND?REFERRAL=1192676&SOURCE=PINTEREST](https://www.rawpixel.com/image/1218228/colorful-camouflage-patterned-background?referral=1192676&source=pinterest)
BLACK AND WOODEN CHAIR [HTTPS://WWW.LATIMES.COM/STYLE/LA-HM-ETNISSIDE13-2008SEPT13-STORY.HTML](https://www.latimes.com/style/la-hm-etniesside13-2008sept13-story.html)

MONOCHROME MINIMALISM

SHARP SHINY KITCHEN RENDER [BLACK'N WHITE KITCHEN INTERIOR BY VOSERNA ON DEVIANTART](#)
CILINDRICAL LAMPS [HTTPS://WWW.ARCHIPRODUCTS.COM/EN/PRODUCTS/DELIGHTFULL/ALUMINIUM-WALL-LIGHT-GALLIANO-WALL-LIGHT_55429](https://www.archiproducts.com/en/products/delightfull/aluminium-wall-light-galliano-wall-light_55429)
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DRONE WALL LIGHT [HTTPS://WWW.SIENNADESIGN.CO.NZ/FURNITURE/](https://www.sienнадesign.co.nz/furniture/)
BRAUN LE03 [HTTPS://BRAUN-AUDIO.COM/EN-GLOBAL](https://braun-audio.com/en-global)
SUPREMATISM ART [HTTPS://EN.WIKIPEDIA.ORG/WIKI/BLACK_SQUARE_\(PAINTING\)](https://en.wikipedia.org/wiki/Black_square_(painting))
WHITE INTERIOR [HTTPS://WWW.FACEBOOK.COM/GODSPEEDITCREATION/](https://www.facebook.com/godspeeditcreation/)
PIET MONDRIAAN ART [HTTPS://COMMONS.WIKIMEDIA.ORG/WIKI/FILE:PIET_MONDRIAAN,_1921_-_COMPOSITION_EN_ROUGE,_JAUNE,_BLEU_ET_NOIR.JPG](https://commons.wikimedia.org/wiki/File:Pieter_Mondriaan,_1921_-_Composition_en_rouge,_jaune,_bleu_et_noir.jpg)
BLACK WIND CHIME [HTTPS://MERLYNWEBSHOP.BE/AUREOLE-TUNES-WIND-CHIME-106CM-BLACK-P42311949](https://merlynwebshop.be/aureole-tunes-wind-chime-106cm-black-p42311949)
BAUHAUS CHAIR [HTTPS://WWW.MOMA.ORG/COLLECTION/WORKS/2851](https://www.moma.org/collection/works/2851)
MIRROR [HTTPS://WWW.DANTE.LU/PRODUCT/WONDERLAND/](https://www.dante.lu/product/wonderland/)
GEOMETRIC SHELF [HTTPS://WWW.TARGET.COM/P/36-34-X-24-34-PIRZADA-GEOMETRIC-WALL-SHELF-BLACK-KATE-38-LAUREL-ALL-THINGS-DECOR/-/A-82864920](https://www.target.com/p/36-34-x-24-34-pirzada-geometric-wall-shelf-black-kate-38-laurel-all-things-decor/-/A-82864920)
BRAUN BC02 CLOCK [HTTPS://WWW.BOL.COM/NL/NL/P/BRAUN-BC02-KWARTSWEKKER-ZWART/9200000125701380/](https://www.bol.com/nl/nl/p/braun-bc02-kwartswekker-zwart/9200000125701380/)
BLACK-WHITE INTERIOR [HTTP://WWW.HOME-DESIGNING.COM/2014/01/INTERIOR-DESIGN-IN-BLACK-WHITE](http://www.home-designing.com/2014/01/interior-design-in-black-white)
OVAL WALL SHELF [HTTPS://WWW.BEDBATHANDBEYOND.COM/STORE/PRODUCT/RIDGE-ROAD-DECOR-IRON-MODERN-WALL-SHELF-IN-BLACK/5615036?BRANDID=7272&PLPPAGE=2&PLPPERPAGE=24](https://www.bedbathandbeyond.com/store/product/ridge-road-decor-iron-modern-wall-shelf-in-black/5615036?brandid=7272&plppage=2&plpperpage=24)

RUSTIC AND NATURAL

RECYCLED PAPER CHAIRS [HTTPS://WWW.CODA-APELDOORN.NL/NL/AGENDA/CODA-PAPER-ART-2021](https://www.coda-apeldoorn.nl/nl/agenda/coda-paper-art-2021)
BLACK AND WOODEN CHIME [HTTPS://WWW.OSDORP.NL/PRODUCT/179643/WINDGONG-WINDGONG-CA-120CM-ZWART-SYMPHONY-TUNES](https://www.osdorp.nl/product/179643/windgong-windgong-ca-120cm-zwart-symphony-tunes)
WOODEN PENDANT LIGHTS [HTTPS://WWW.NEDGIS.COM/EN/PRODUCTS/PENDANT-LIGHT-CHIMES-3000K-220LM-WOOD-BROWN-LED-O3CM-H22CM-UMAGE](https://www.nedgis.com/en/products/pendant-light-chimes-3000k-220lm-wood-brown-led-o3cm-h22cm-umage)
WOOD GRAIN KNOT [HTTPS://NL.PINTEREST.COM/PIN/400116748116630199/](https://nl.pinterest.com/pin/400116748116630199/)
RUSTIC GASTROBAR INTERIOR [HTTPS://WWW.ESSENTIALHOME.EU/BLOG/RUSTIC-INTERIOR-DESIGN-MEETS-LUXURY-GASTROBAR-SPAIN/](https://www.essentialhome.eu/blog/rustic-interior-design-meets-luxury-gastrobar-spain/)
GRUBA RECYCLED WOODEN CHAIR [HTTPS://WWW.GRUBA.COM.AR/S-O-S-BARRIO](https://www.gruba.com.ar/s-o-s-barrío)
BEACHGLASS WIND CHIME [HTTPS://WWW.WALMART.COM/IP/BEACH-GLASS-AND-DRIFTWOOD-WIND-CHIME-SANDBLASTED-GLASS-PLEASANT-GENTLE-SOUND-FOUND-WOOD-BY-BLUE-HANDWORKS/795974345?ATHBDG=L1700](https://www.walmart.com/ip/Beach-Glass-And-Driftwood-Wind-Chime-Sandblasted-Glass-Pleasant-Gentle-Sound-Found-Wood-By-Blue-Handworks/795974345?athbdg=L1700)
PHE SCRAPWOOD CHAIR [HTTPS://FROZENFOUNDTAIN.COM/PRODUCTS/OAK-CHAIR-IN-SCRAPWOOD](https://frozenfoundtain.com/products/oak-chair-in-scrapwood)
TIRE AND WOODEN CHAIRS [HTTPS://VIRALDECORATIONS.COM/IDEAS-CHAIRS-OTTOMAN-AND-TABLES-MADE-FROM-TIRES/32/](https://viraldecorations.com/ideas-chairs-ottoman-and-tables-made-from-tires/32/)
FULL TIRE CHAIRS [HTTPS://NL.PINTEREST.COM/PIN/371617406757111542/](https://nl.pinterest.com/pin/371617406757111542/)
BAMBOO WIND CHIME [HTTPS://WWW.AMAZON.COM/MUMTOP-BAMBOO-OUTDOOR-WOODEN-CHIMES/DP/B07R6MFP5K?TH=1](https://www.amazon.com/Mumtop-Bamboo-Outdoor-Wooden-Chimes/DP/B07R6MFP5K?th=1)
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PHE & IKEA CHAIR [HTTPS://PIETHEINEEK.NL/PRODUCT/IKEA](https://pietheineek.nl/product/ikea)
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WOODEN BOARD [HTTPS://WWW.SHUTTERSTOCK.COM/IMAGE-PHOTO/OLD-WOODEN-BOARD-BACKGROUND-109472384](https://www.shutterstock.com/image-photo/old-wooden-board-background-109472384)

APPENDIX D - DESIGNED MATERIAL EXPLORATION



Figure D.1: All material assemblies laid out for exploration

A finalized concept consists of multiple parts; in the case of Feng the sound of the product and interaction in which a user interacts with these sounds of course play the main parts in the functionality of the service, yet the aesthetics decide the desirability through visuals in advertisement which catches potential customer's eyes and draws them in to learn more about the product.

This is why it is important for designers to make sure that the materials used in a final product both look and feels appropriate to their use-case. To achieve this certainty and underline the exploratory nature of choosing the correct properties of a physical product, an experience was developed through UX design for the design team behind Feng to guide them through making aesthetic and structural choices for their product.

Before being able to design this exploration event, the broadest array possible of materials had to be collected and this was guided by the availability in the real world. By breaking down materials to rectangles of the same size, the matter could be disconnected from the existing products it originated from; resulting in samples that could be interacted with to investigate the tactile properties of each, but still could be easily identified for further research by the labeling of the materials used.



Figure D.2: A collage of every collected material sample

Then the digital mood boards were implemented into boxes for the garnered materials to be placed into, as this combined the two factors to singular assemblies that allowed all of the past work to compliment each other. These boxes had to be specifically designed to allow for full visibility of and interaction with the samples when opened and the two ideations below were done, with the right figure being the final template as it folded down almost completely flat and thus showcase the materials the best.

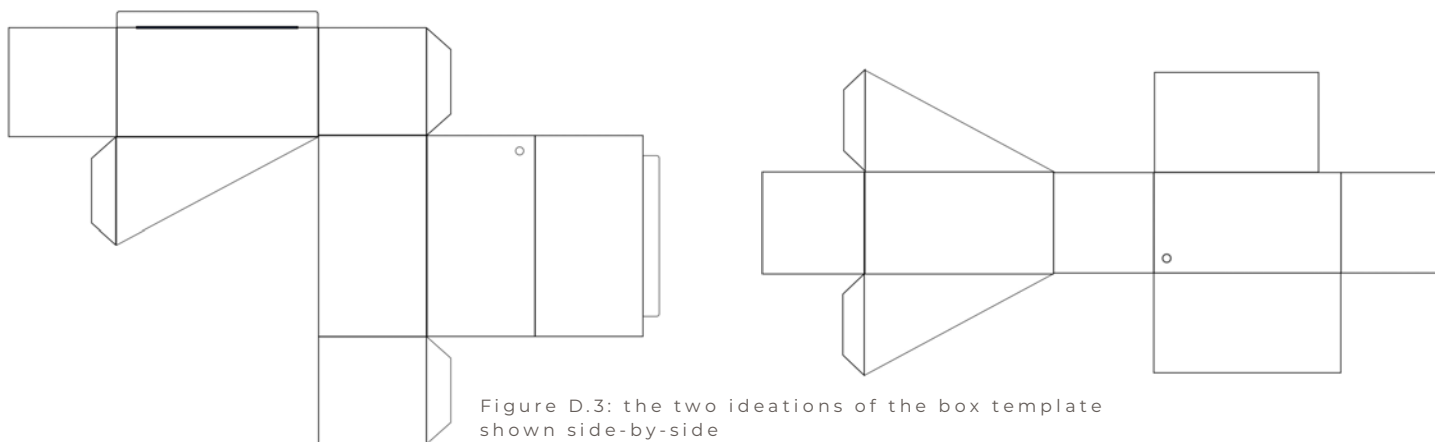


Figure D.3: the two ideations of the box template shown side-by-side

As this assembly was supposed to be sturdy so it could be useful in further design processes and to not lose any of the samples, they were held together with hardware seen below that was custom made for each category as to enhance the aesthetics and thus stimulate the designers more to interact with even the boxes and pay attention to the smaller details. A front cover on each stack of samples that represented the spirit of each aesthetical category was implemented for the same purpose.

Figure D.4: The hardware to accompany each style category



The adamant implementation of these four themes instead of presenting all samples separately was done to stimulate a starting point of exploration: as everyone gets drawn to different textures, colors or shapes, they start interacting with different assemblies, which will make less samples get overlooked and spark more discussion; thus leading to a well-thought-through solution at the end of the phase. The design of this experience may affect the ability to see the materials itself separate from the genre even though colors could potentially be changed to fit other styles. Even so, this was the most structured and pleasing way to shape the experience given the time restraints at hand.



Figure D.5: A series of pictures outlining the way the material assemblies should be used to stimulate exploration to the fullest

APPENDIX E

PHYSICAL PROTOTYPE

E.1 CODE

PROCESSING CODE SNIPPET

```
import processing.serial.*;
import processing.sound.*;

//49,50,51,52
// 1, 2, 3, 4

String Scenario = "1";

SoundFile hSound;
SoundFile aqSound;
SoundFile afSound;
SoundFile tSound;

Serial myPort;
int val = 0;
int readval;

void setup() {
  print(Serial.list());
  myPort = new Serial(this, Serial.list()[4], 9600);

  hSound = new SoundFile(this, "humidity"+Scenario+".wav"); //humidity
  sound file
  aqSound = new SoundFile(this, "air_quality"+Scenario+".wav");//air
  quality sound file
  tSound = new SoundFile(this, "temperature"+Scenario+".wav");
  //temperature sound r
  afSound = new SoundFile(this, "air_flow"+Scenario+".wav"); ; //air
  flow sound file
  //hSound.play();
}

void draw() {

  readval = myPort.read();
  //print(readval);
  if (readval==49) {
    hSound.play();
  } else if (readval == 50) {
    aqSound.play();
  } else if (readval == 51) {
    tSound.play();
  } else if (readval == 52) {
    afSound.play();
  }
}
```

ARDUINO CODE

```

#include <Arduino.h>
#include <stdio.h>

#include <Servo.h>

Servo myservo[4]; // create servo object to control a servo

int servoPos[4][4]={{180,180,180,180},{0,0,0,0},{180,50,120,0},{0,30,70,120}};

//sensor variables
int sensor[4] = {A1, A2, A3, A4};
//int LED = 13;
int names[] = {1,2,3,4};

int present_condition[4] = {0, 0, 0, 0};
int previous_condition[4] = {0, 0, 0, 0};

long previousTime[4] = {0, 0, 0, 0};
long currentTime[4] = {0, 0, 0, 0};
const long interval = 2000;//interval that one object can play sounds in

//midi variables
boolean midiMode = false;//enables n disables the midi or debug mode
int vel[4] = {100, 76, 127, 100};
int note[4] = {1, 2, 3, 4};

void setup() {

  for(int x = 0; x<4; x++){
    myservo[x].attach(2+x);
  }

  if (midiMode) {
    Serial.begin(115200); // this is the standard communication baudrate for MIDI
    devices, do not change this!
  }
  else {
    Serial.begin(9600);//to debug the sensors
  }
  for (int x = 0; x < 4; x++) {
    pinMode(sensor[x], INPUT);
  }
}

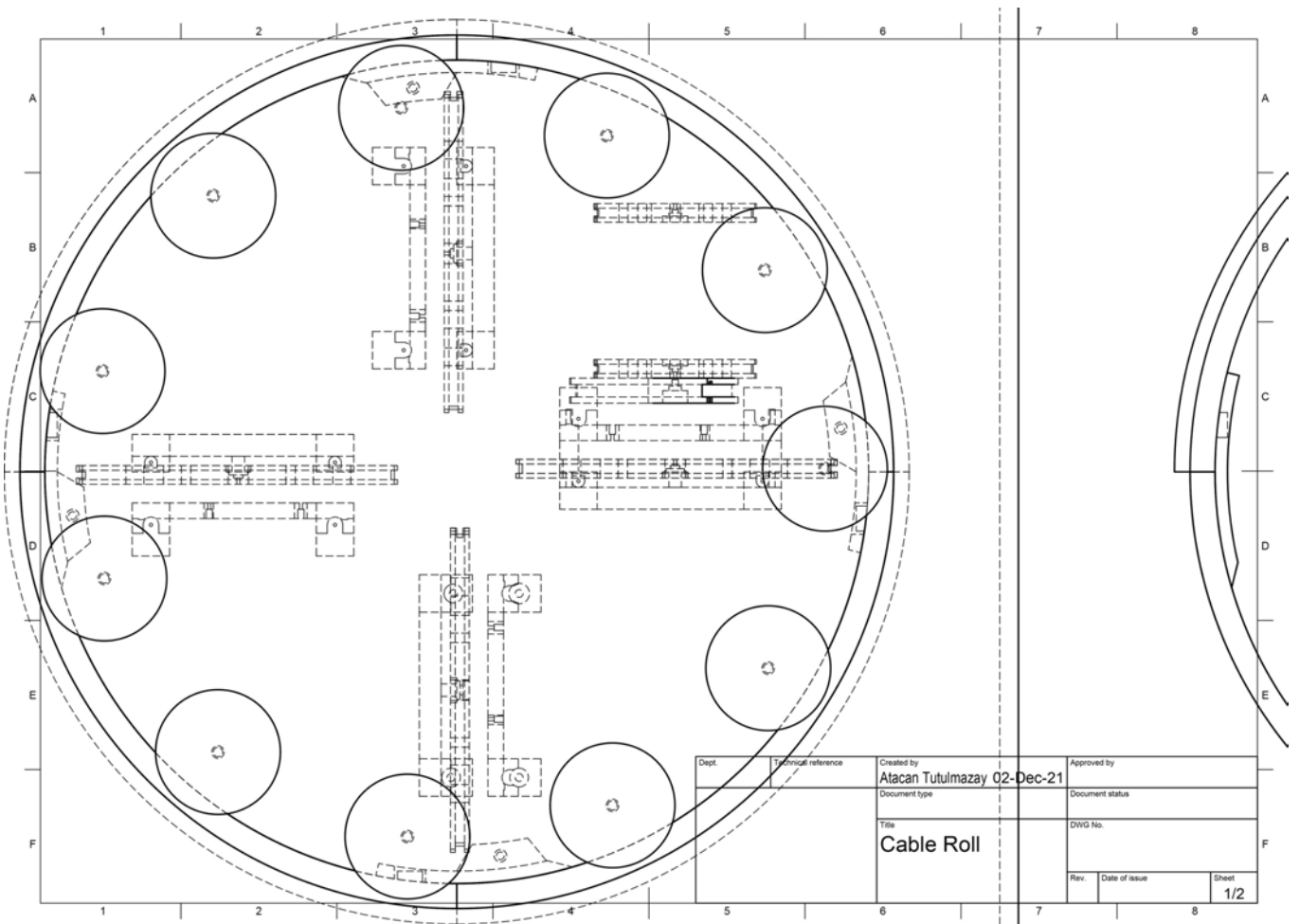
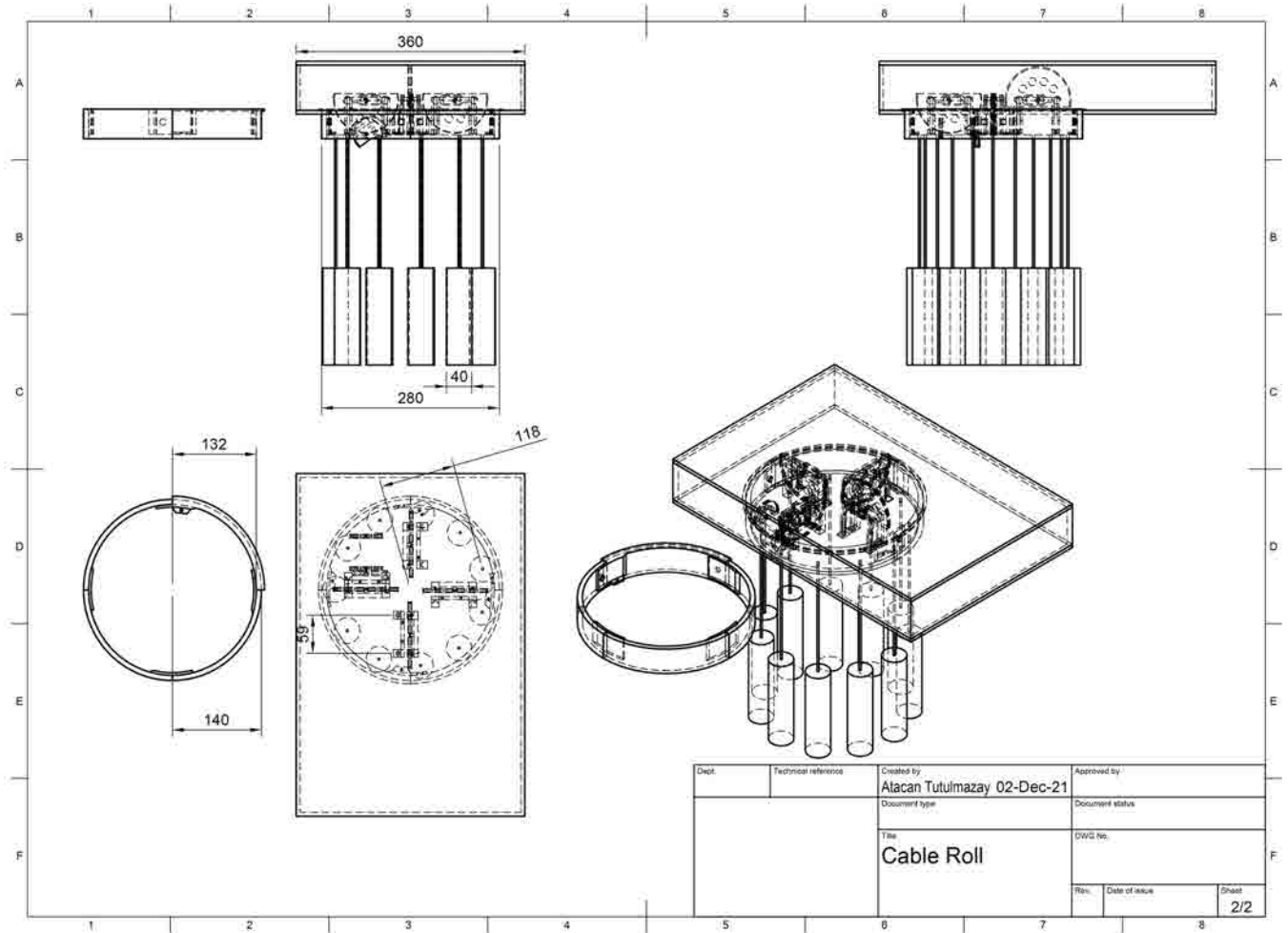
void loop() {

  for (int x = 0; x < 4; x++) {

    myservo[x].write(servoPos[1][x]);
    previousTime[x] = currentTime[x];
    previous_condition[x] = present_condition[x];
    present_condition[x] = digitalRead(sensor[x]); // Reading digital data from the
    sensor0 Pin of the Arduino.

    if (digitalRead(sensor[x]) == HIGH) {
      currentTime[x] = millis();
    }
    if (previous_condition[x] != present_condition[x] && (currentTime[x] -
    previousTime[x]) >= interval) {
      if (!midiMode) {
        Serial.print(names[x]);//debug for sensor portion
      }
      else {
      }
    }
  }
}

```



APPENDIX F - USER TESTING DOCUMENTS

F.1 PROTOCOL

Purpose and goal of the evaluation

The goal of the evaluation is to find points of improvement regarding the design that is being evaluated. The points of improvement will mainly be targeted towards the intuitiveness of using the design as well as the sounds that the design makes.

Target population and recruitment strategy

The target population is anyone that can be a potential user, this is anyone who lives indoors. For ethical reasons children as well as vulnerable people are to be excluded from the study. Experts on the area of sound design are also to be excluded, since their prior knowledge on how to interpret sounds can produce unreliable test results.

Specific research questions

- How can the design be improved to be more intuitive?
- How can the sounds be improved to be more intuitive?
- What is the cognitive load of using the design altogether?

Introduction to the study (as to be read to the participant) prior to interacting with the design

This is a prototype of Feng, a device that is meant to tell you about the air quality inside your house.

Testing task (as to be presented to the participant)

You will be asked to interact with the device while thinking out loud. You will also be asked to fill out a questionnaire and SMEQ analysis. Lastly, the design will be discussed in a semi-structured interview format.

Observation and think aloud protocol

While observing the participant interacting with the prototype, they are asked to think aloud, which means they will say everything that comes to mind while interaction with the design along with any assumptions they make or impressions they are left with.

Post test measures

After the test, the participant is thanked for their participation in the evaluation and will leave, after which the researchers quickly discuss the results.

Semi structured interview guide

For the semi-guided interview, a list of questions is used that are thought to help achieve the goal of this evaluation. The list of questions can be found below.

1. Right of the bat, what was your first impression interacting with Feng?
2. Was it clear in which way you were meant to interact with Feng?
3. How did you perceive fluctuation of the height of the weights?
4. What do you think it means when the weight hangs all the way at the top?
5. What do you think it means when the weight hangs all the way at the bottom?
6. Were you able to distinguish the different sounds from each other?
7. What do you think the different sound could mean?
8. How long do you think it would take you to memorize the different sounds?
9. Do you think the interaction serves the purpose it's meant to? Why or why not?
10. Where in the house would you place Feng? Why would you place it in this location?
11. Can you think of any improvements to make Feng more usable?
12. Can you think of any improvements to improve the user experience of Feng?
 - Duration of sounds?
 - Touch and feel?
 - Height of the weights

Equipment and logistics

For the evaluation, only the prototype, sound speaker and laptop are required equipment. Aside from that the evaluation has to be performed in an area where the prototype can be installed on the proper height.

Ethical considerations

The study was ethically approved by going through the Ethical Review Board checklist and having it signed off by the project coach.

F.2 COGNITIVE LOAD ASSESMENT DATA

Participants Millimeters

participant 1	16
participant 2	27
participant 3	28
participant 4	20
participant 5	49
participant 6	30
participant 7	102

F.3 COLOR CODES

Design - Dark green

cluttered/busy - Red

manual - grey

location - turquoise

Sounds - Purple

distinguishing- green

memorizing - yellow

Intuitiveness - Light blue

F.4 TRANSCRIPTS

Participant 1

I: Right of the bat, what was your first impression interacting with Feng?

Yeah, it felt a lot like the normal windchimes, it looked like that, so that was my first impression. You could just push around with it and it kind of acted like a windchime.

I: Was it clear in which way you were meant to interact with Feng?

I just pushed it around, normally there is wind so I don't know how the user itself is to interact with it. I just pushed it around so if that was sufficient, then yes.

It was just hanging there, the natural reaction is to hit it. And to interact with it in that way, so yeah.

I: How did you perceive fluctuation of the height of the weights?

When they're all up it feels a bit cluttered. Then when some are down it feels more nice and natural, so in that way only the attractiveness would change in that. I don't see a further value to the height of the weights.

I: Were you able to distinguish the different sounds from each other?

All of them had a nice melodic sound in them, but then at the end there was a distinguish between most of them. You couldn't really recognize what the sounds were exactly, but they were different. So you had for example the broom and waves or the air you could really differentiate between them, but only on the last part of the sound.

I: You say that last part, did you hear differences in the beginning too or was that always the same to you?

Yeah no, maybe if you put them together I would know. But if there's a delay between I don't think I would have noticed. They're just melodic sounds.

I: When you heard the sounds, did you feel like they had a meaning?

Yeah, with some of the sounds you could relate to it with something like an object, I gave the example with the broom. You could hear the sound, relate that sound to an object and you could relate that to a sound with a meaning. So yeah in that way the sounds felt like they had a meaning, because they represent a familiar sound.

I: What do you think the different sound could mean?

I: How long do you think it would take you to memorize the different sounds?

Yeah I think that with like the proper training, or if you hear it a few more times you could really distinguish it. The were not really the same, but some of them don't really have a feeling with it, but if you know what they mean you could definitely learn it.

I: Do you think the interaction serves the purpose it's meant to? Why or why not?

I: Where in the house would you place Feng? Why would you place it in this location?

I think right now it's quite low hanging and at the same level of your eyes. I would place it somewhere a bit windy, somewhere high, above your head so it wouldn't be in your way. Not really in sight, but close enough that you can see and interact with it.

I: Can you think of any improvements to make Feng more usable?

I: Can you think of any improvements to improve the user experience of Feng?

- Duration of sounds?

- Touch and feel?

The tubes were too big, I would like a lighter color, something like silver since it fits chimes more. I would definitely keep the height variations.

Participant 2

I: Right of the bat, what was your first impression interacting with Feng?

It's quite enjoyable, very interesting to interact with it. It's almost like you're playing with it. But while playing with it I would struggle with finding out what the exact function is. With a user manual it would for sure be more understandable. I did find out what it was, but if I had a user manual it would help connecting what element connects to what.

I: Was it clear in which way you were meant to interact with Feng?

Yes I wanna touch it, I wanna move it and there's a sound telling me it worked. So yes, the interaction is clear, but the step of translation is what for me is still missing.

I: Do you think that last step of translation is important to create that wholesome interaction.

I would say so, otherwise I'm just playing with something. By adding that last step, I would know the purpose of it and by interacting it would communicate something to me.

I: Would then the information be the number one reason for you to interact with it?

Yeah, looks wise it looms interesting to interact with but it's not an art installation. So the eventual meaning of it would lead me to either play or interact with it more.

I: Where in the house would you place Feng? Why would you place it in this location?

For now, I see it somewhere in the living room in a corner. Kind of out of view but you can still see it. Something you can focus on but it doesn't get in the way.

I: How did you perceive fluctuation of the height of the weights?

I like how it moved, as soon as there was a difference of height it was kind of interesting. It certainly got me thinking; do the different levels mean something. At first it looked like a normal wind chime, but as soon as it started to move it means that it's doing something.

I think height could correlate to for example high pressure, low pressure zone, or high or low humidity. I think the levels could indicate like how important it is, so if it's a low humidity, it will be low since that's a bad thing. Perfect air quality would be all of them at the same height.

I: Say one hangs a lot lower, would that invite you to interact with it?

I would say so, it would kind of freak me out. Because say there's something wrong; I need to fix this. So I would interact with it since it's illustrating that there's something wrong.

I would want to have the most negative quality lowest, since negative is sort of logically down.

I: Were you able to distinguish the different sounds from each other?

Yeah kind of, there all kind of in the same ranges. They all sounded fairly ominous, some were higher other lower. Say there were sounds that are suppose to convey positive factors I would make them either higher pitched or happier.

For me it would make it clearer if the ominous base sounds would also fluctuate.

Participant 3

I: Right of the bat, what was your first impression interacting with Feng?

I really liked it, I like how it's inspired from actual wind chimes for something related to like air quality and air. It's nice to see something technical in combination with something mechanical that's been used for a long time. And I like the usage of wood.

I: Was it clear in which way you were meant to interact with Feng?

Not extremely, I could tell it served different purposes and that levels and sounds meant different things. My first instinct was to pull instead of push the pendulums. It was giving me clear feedback.

I: How did you perceive fluctuation of the height of the weights?

I assumed it was just different levels, I don't know what levels of. So maybe for a low humidity it hangs low.

I: would you feel more alarmed if a weight was extremely high or low?

For some reason I would be more alarmed if one was really high. Cause it's more close to me, but that is my height. It would push me to quicker interact with it.

I: Were you able to distinguish the different sounds from each other?

I don't think so, I heard wind and water. I don't know if there was a third sound or whether I was mistaken, I might have heard something crumbling or even burning.

I: How long do you think it would take you to memorize the different sounds?

It would take a while since I couldn't really distinguish between them. So maybe make them more distinct, also the chime sounds were at the beginning so if you make them more upfront and distinct I would be able to tell which one is one.

I would just lower the volume of the chime so the distinct sound becomes more clear.

I: Do you think the interaction serves the purpose it's meant to? Why or why not?

Yes, if I had know which one is what I would definitely know how to use it. A manual would help a lot as well.

I: Where in the house would you place Feng? Why would you place it in this location?

I would place it at the entrée at something, so it has access or see most rooms. Something you frequently check and that's maybe something you want to do as you come into the house.

I: Can you think of any improvements to make Feng more usable?

Try to add more indicators, not just sounds. Maybe even colors as feedback.

I: Can you think of any improvements to improve the user experience of Feng?

I: How long do you think it would take you to memorize the different sounds?

I think I would memorize them fairly quickly. It depends on variety of the sounds, as you described them earlier they do sound very different, even though they weren't that easy to distinguish, but I think that you can definitely learn it quickly.

I: Do you think the interaction serves the purpose it's meant to? Why or why not?

It needs a manual for me, but as soon as I have that it does serve its purpose. It's a creative way of illustrating how the air quality is and it makes it more interactive than just reading it of a screen.

Participant 4

I: Right of the bat, what was your first impression interacting with Feng?

It was definitely fun to interact and reaction I get from the device is actually fun and exciting. But I found it a little bit hard to understand without any explanation. But it was actually fun to use the device.

I: Was it clear in which way you were meant to interact with Feng?

It is clear how I should interact, but the response wasn't that clear in my opinion. I had to see the different situations in order to understand what the device is telling me, so I wouldn't see it's really easy to understand what it's telling me. But I think that when it does it gives me a clear understanding of air quality.

I would love to see an indication of what I'm looking at, and to see if it's ready to interact with

I: How did you perceive fluctuation of the height of the weights?

I still think the heights, just like the sound, the harmony, convey the problems. When all have the same height they have the optimal air quality, the sounds also make that clear. When they hang lower, the air quality is worse.

I: Were you able to distinguish the different sounds from each other?

Yes, but I couldn't understand their meaning.

I: How long do you think it would take you to memorize the different sounds?

Not long at all, they're all very self-explanatory.

I: Do you think the interaction serves the purpose it's meant to? Why or why not?

Yeah it does, of course if I would know what everything meant it would be much easier. But now I understand it would definitely serve its purpose.

I: Where in the house would you place Feng? Why would you place it in this location?

Somewhere in the living room, it's the center of my house where I spend the most time. So interacting would become easier spread out over the day.

I: Can you think of any improvements to make Feng more usable?

My suggestions would be to add another way to communicate the air quality, maybe something visual since I don't think everyone will be able to differentiate between the sounds. Maybe make the pendulums glow or something, you need a clearer way to make the point come across.

I: Can you think of any improvements to improve the user experience of Feng?

Participant 5

I: Right of the bat, what was your first impression interacting with Feng?

It made pretty sounds, I didn't really know what to do so I just tapped it and it was weirdly relaxing.

I: Was it clear in which way you were meant to interact with Feng?

Not so much, I didn't know whether to tap or pull it or whatever?

I: How did you perceive fluctuation of the height of the weights?

I didn't think much about it, there's probably a meaning tied to it or it would be kind of useless. It makes sense that you interact first with the once closest, thus lowest ones.

I: Were you able to distinguish the different sounds from each other?

Not that much, I wasn't really focusing on the sounds but more on when it was playing them.

I: Where in the house would you place Feng? Why would you place it in this location?

I don't know much you'd use it, it also depends on urgency. The living room makes most sense I'd say, since it also usually has the most space. It's more accessible and more central so that makes sense.

I: Can you think of any improvements to make Feng more usable?

I would add something with light, it would make it a bit clearer.

I: Can you think of any improvements to improve the user experience of Feng?

Participant 6

I: Right of the bat, what was your first impression interacting with Feng?

I thought it was interesting and cool, the sounds were interesting and made me think of a lot of different things.

I: How did you perceive fluctuation of the height of the weights?

I think they related to on which floor of the house it was, that could also explain why we couldn't hear the top ones since they're too far away. SO the higher, the further away the room is.

I: Were you able to distinguish the different sounds from each other?

They all made a scene in my head, I thought I heard a train which didn't really make sense. I could easily distinguish between all of the sound.

I: How long do you think it would take you to memorize the different sounds?

It would be quite easy I think, they seemed to differ a lot.

I: Do you think the interaction serves the purpose it's meant to? Why or why not?

The sounds were different but not too different, so I think it would definitely work.

I: Where in the house would you place Feng? Why would you place it in this location?

Probably in a kitchen, a common area where it wouldn't cover so much space but everyone could touch it or use it when they see it.

I: Can you think of any improvements to make Feng more usable?

With so many ropes it's hard to pick one pendulum at once, especially if you have unsteady hands or something similar. I would try adding less ropes if possible, I wouldn't make it bigger since it's already quite big.

Participant 7

I: Right of the bat, what was your first impression interacting with Feng?

I was curious and wondered since it was very different from other things I've seen before, it really caught my interest

I: Was it clear in which way you were meant to interact with Feng?

Not really, when I touched it I understood that it was reacting to some kind of mechanical input. But I wasn't really understanding what about me moving it made it make a sound, I needed some minutes to get a feeling for it.

I: How did you perceive fluctuation of the height of the weights?

The changes didn't seem that big, so it didn't make much of a different. The first scenario seemed more organic since there was more dispersion. I had no clue what the height meant, it also didn't really effect my decision making. I liked swinging the lower ones more, but in general what really drove my decisions was which ones reacted and which ones didn't.

I: Were you able to distinguish the different sounds from each other?

Not really, it was quite hard for me. It took me quite some attention and I had to repeat them. The melodies seemed very similar, and also the endings, it was a very subtle difference.

I: When you heard the sounds, did you feel like they had a meaning?

They were all making one big image in my head, I didn't see them as different things.

I: Do you think the interaction serves the purpose it's meant to? Why or why not?

I'd say it makes sense, but I'd need to see bigger differences in height and less clustered. But if I see that I think it would all make sense.

I: Where in the house would you place Feng? Why would you place it in this location?

I was imagining one of these strings in each room, but as a whole somewhere where everyone passes and stops as well, so maybe next to a sofa or in the kitchen. A place where you stop for a second, maybe an entrance hall.