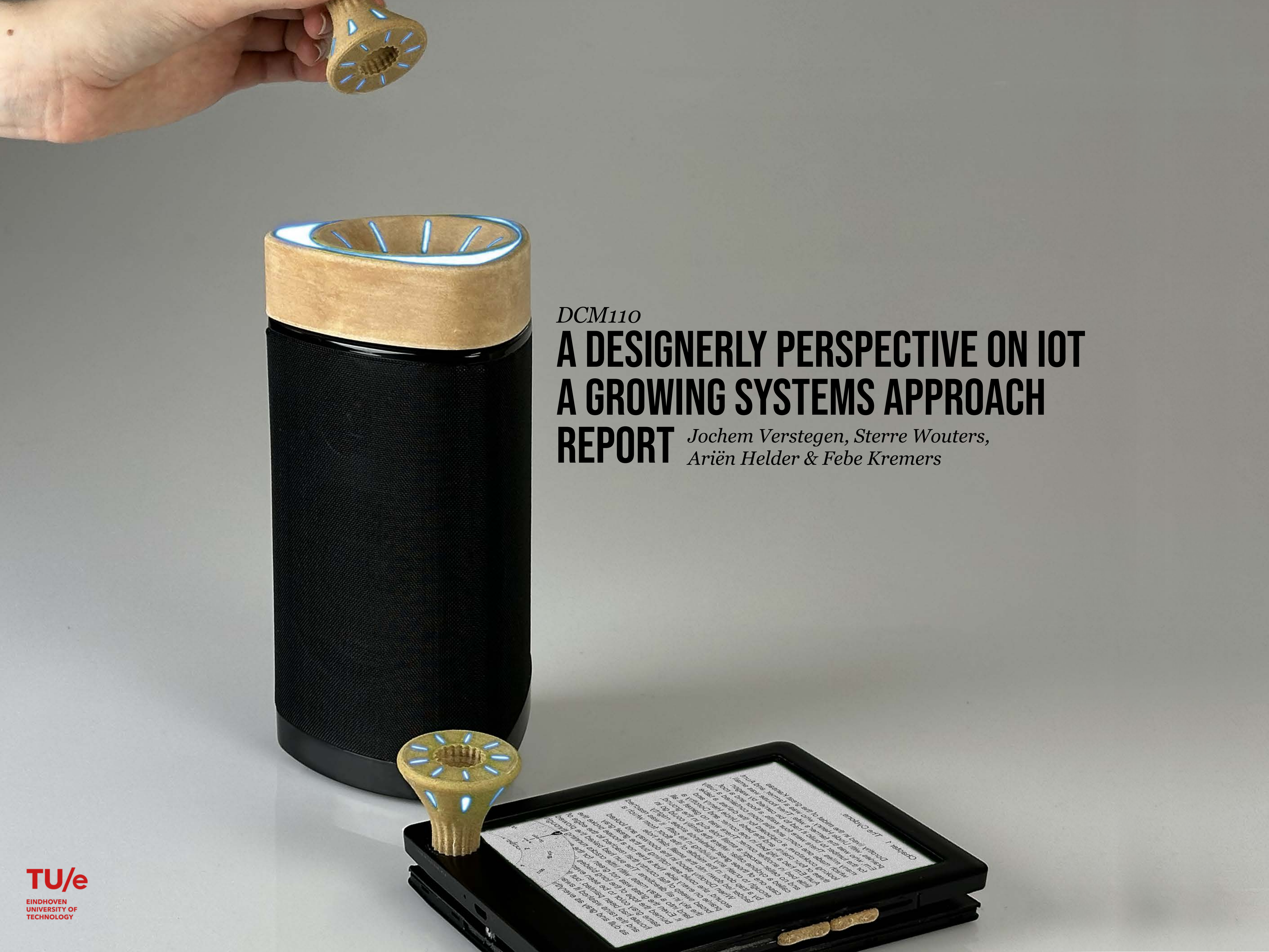

DCM110

A DESIGNERLY PERSPECTIVE ON IOT A GROWING SYSTEMS APPROACH REPORT

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EINDHOVEN
UNIVERSITY OF
TECHNOLOGY

Contents

Figure 1: Concept 2
Rich interaction e-reader

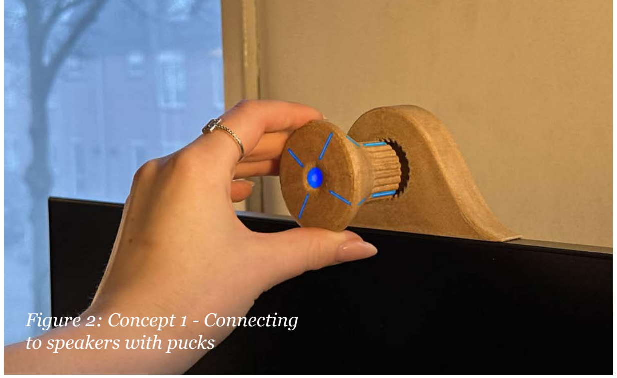


Figure 2: Concept 1 - Connecting to speakers with pucks

Concept 1 and final
Connecting tthe pucks

Figure 3: Final concept
E-reader with audiobook functionality when connected to a speaker

Concept

During this course, we created two concepts that work together. The first concept is a system that physically connects audio sources to speakers to avoid the inconveniences of Bluetooth, such as not knowing what the speaker is called, it not connecting or it suddenly connecting with another device and playing sound from there. You start by connecting the pucks by keeping them against each other, after which they light up in the same colour. After this, you place one on the speaker and the other in the audio source, such as a TV. Both devices "absorb" the colour, showing the connection between each other.

The second concept was a redesign of the e-reader. The e-reader now consists most of the time of only an e-ink touch screen with all the books digitally stored on it. The new e-reader concept is more focused on bringing the physical book experience to an e-reader. With a focus on the progress overview, turning pages and adjusting font size and line distance. To include the ritual for choosing a physical book and storing the books on display, we created book cards to place in the e-reader.

Lastly, we connected these two concepts through audiobooks. The e-reader becomes an audio source after inserting the puck. This combination of books and audiobooks is a combination that goes hand in hand. This concept envisioned that entertainment meets convenience.

Figure 4: Inserting a book

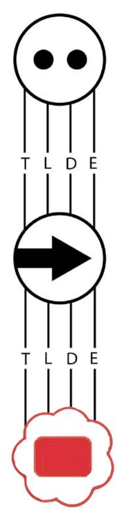


Figure 5: Framework for inserting a book

Rich interaction

To analyse the rich interaction of the e-reader, we used the framework of Lukas van Campenhout [1], along with the concept of affordance and the use of metaphors [12].

Inserting a book

When inserting the book, the pages follow digitally in the same direction on the screen, as shown in Figure 4. This way, the interaction and the visual feedback are coupled on the aspect of unity of direction(D) according to the framework in Figure 5. Furthermore, the user's action and the digital output are coupled in terms of unity of location (L), time (T) and expression (E), respectively because the animation on the screen starts from the same place where you physically insert the book (L), because it happens at the same time as the interaction (T), and because the force of pushing the book into the e-reader is reflected by the speed of the page sliding into the screen (E).

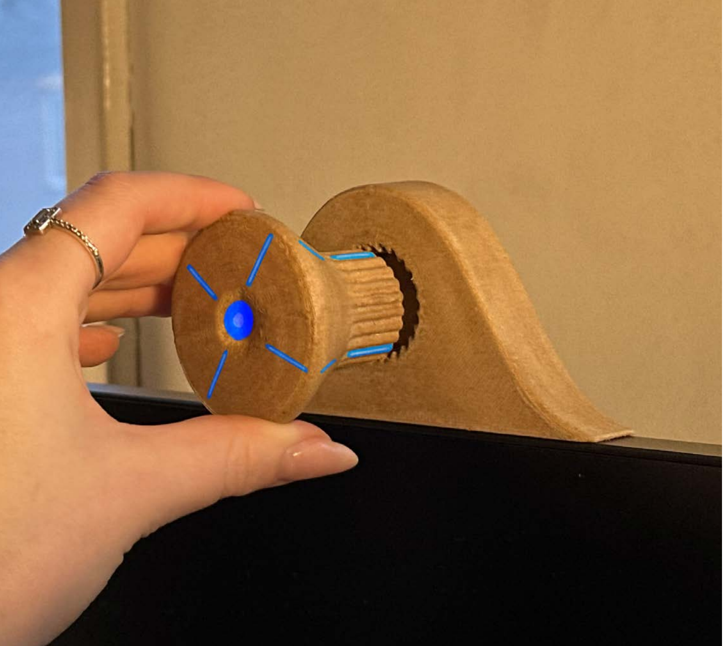


Figure 6: Affordance in assignment 3

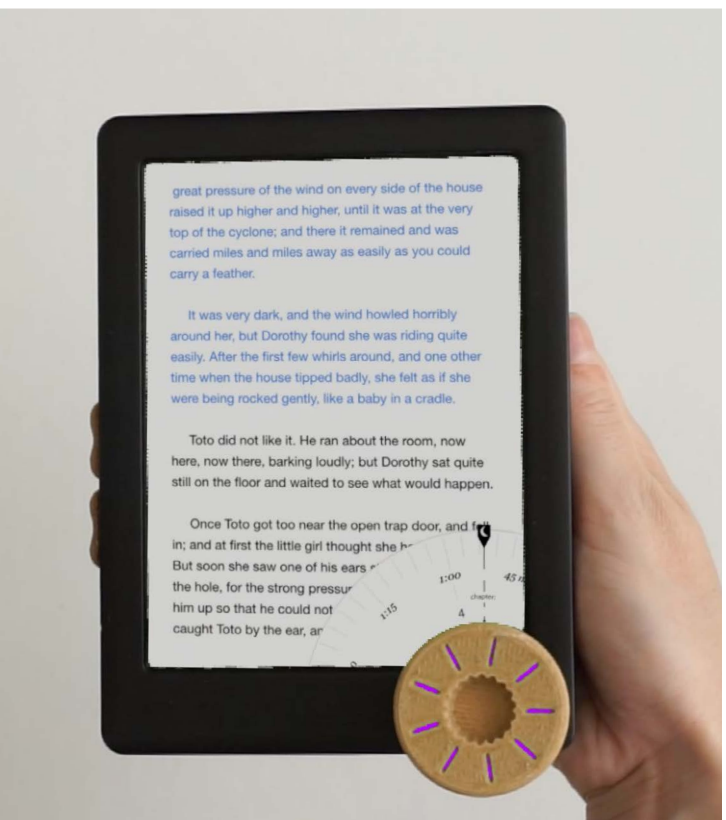


Figure 7: Set listening time

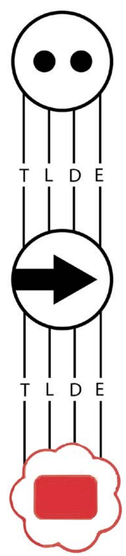


Figure 8: Framework for inserting puck in e-reader

Puck in e-reader

To increase the affordance of inserting the puck in the hole, the hole of the e-reader has the same unique ribbed pattern as the puck does. We already conceptualized this in assignment 3 (see Figure 6).

To set the listening time, you rotate the puck. The highlighting of the text follows the same direction (D) as the rotation of the puck, as can be seen in Figure 7. To also give this interaction expression (E), the speed of rotating affects the speed of selecting. The selection of text switches from lines to pages to chapters depending on the speed at which the puck is rotated. The interaction and feedback are also coupled on the aspect of unity of time (T) because the scrolling wheel appears at the same time as when the puck is placed in the e-reader, and scrolling also happens at the moment of rotating the puck. The scrolling wheel appears directly around the puck to also couple the interaction and feedback based on the unity of location (L). We chose to use the puck as a scroll wheel to make it possible to easily scroll through a long “list” of words, and so a timer can only be set when the audiobook is being read. When not listening to an audiobook, the timer functionality is not needed.

Figure 9: Affordance in assignment 3

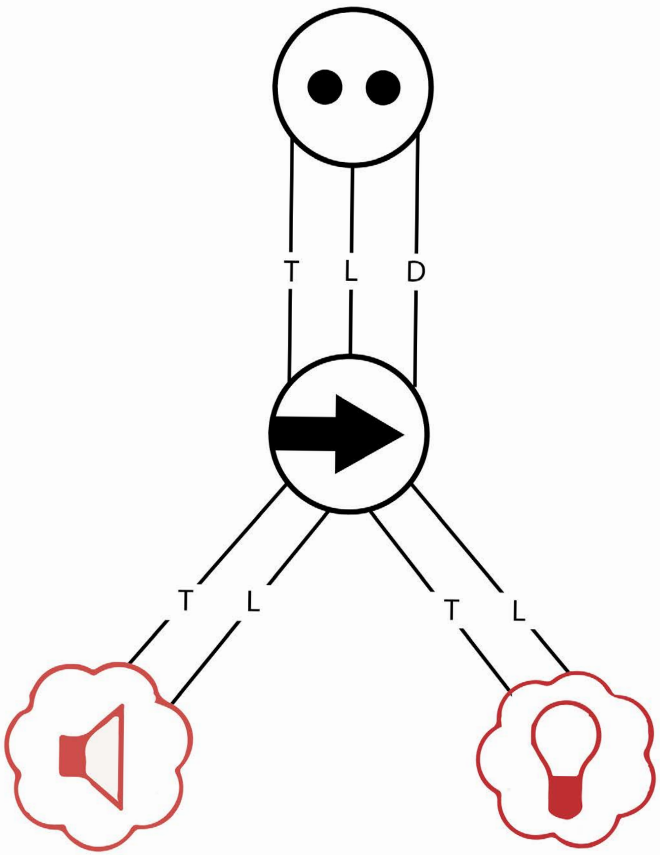


Figure 10: Framework for adjusting volume with puck

Puck on speaker

To increase the affordance of placing the puck on the speaker, the original idea was to have a shape sticking out of the bottom of the speaker, fitting the hole in the puck. In the assignment 3 concept, we executed this with a bump (see Figure 9), which also made rotating the puck easier. Due to time constraints, we did not manage to achieve this in assignment 4.
The ridges on the end of the puck not only offer affordance for fitting the shape into the desired hole but also function as a grip for controlling the volume, with the interaction being similar to volume control on a radio.
The source of the metaphor is the volume control, familiar to the user, and the target domain is controlling the volume on the speaker with the puck functioning as a rotary control, which shows similarities in shape [12].
When the volume is increased, the lights on the speaker get brighter. In Figure 10, it is shown that the feedback and the interaction are coupled based on the unities of location (L) and time (T).

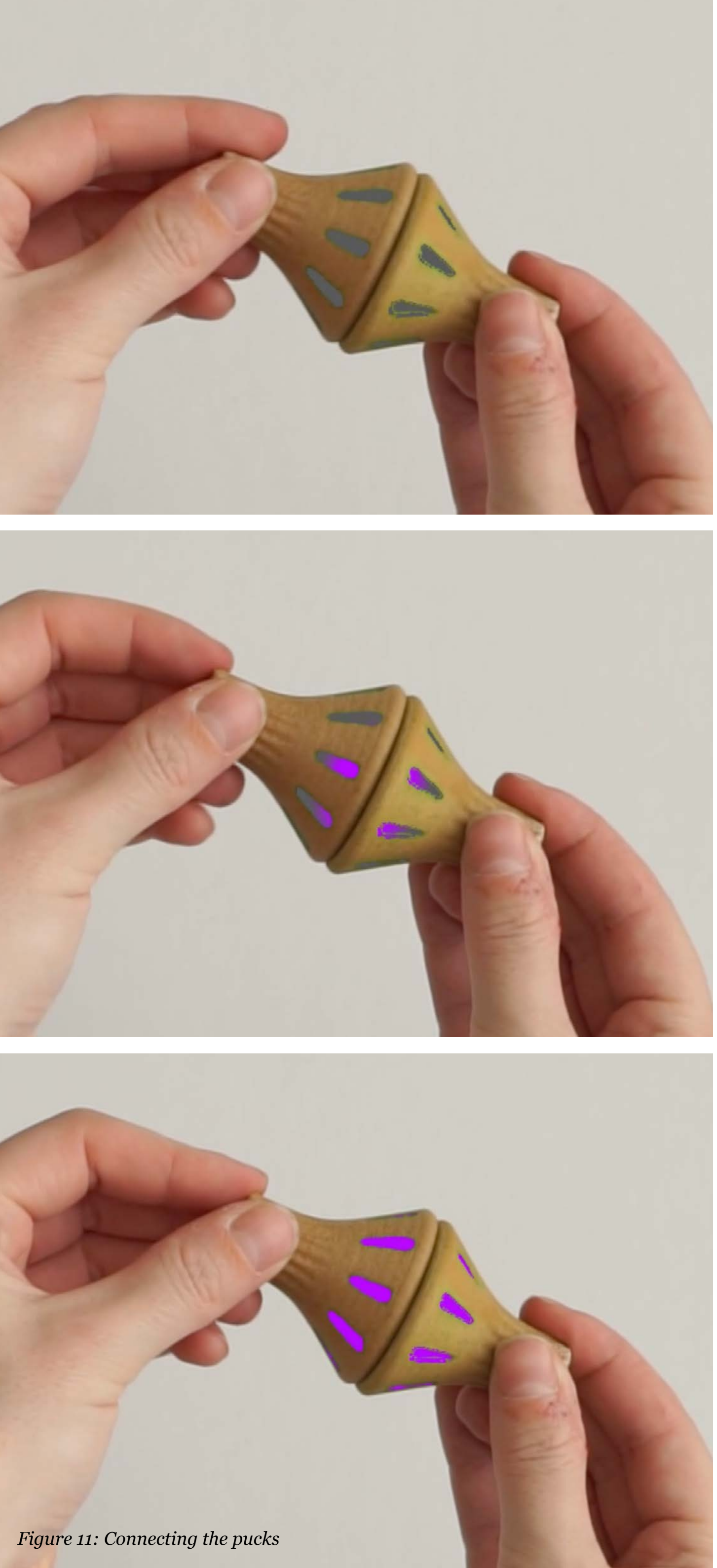


Figure 11: Connecting the pucks

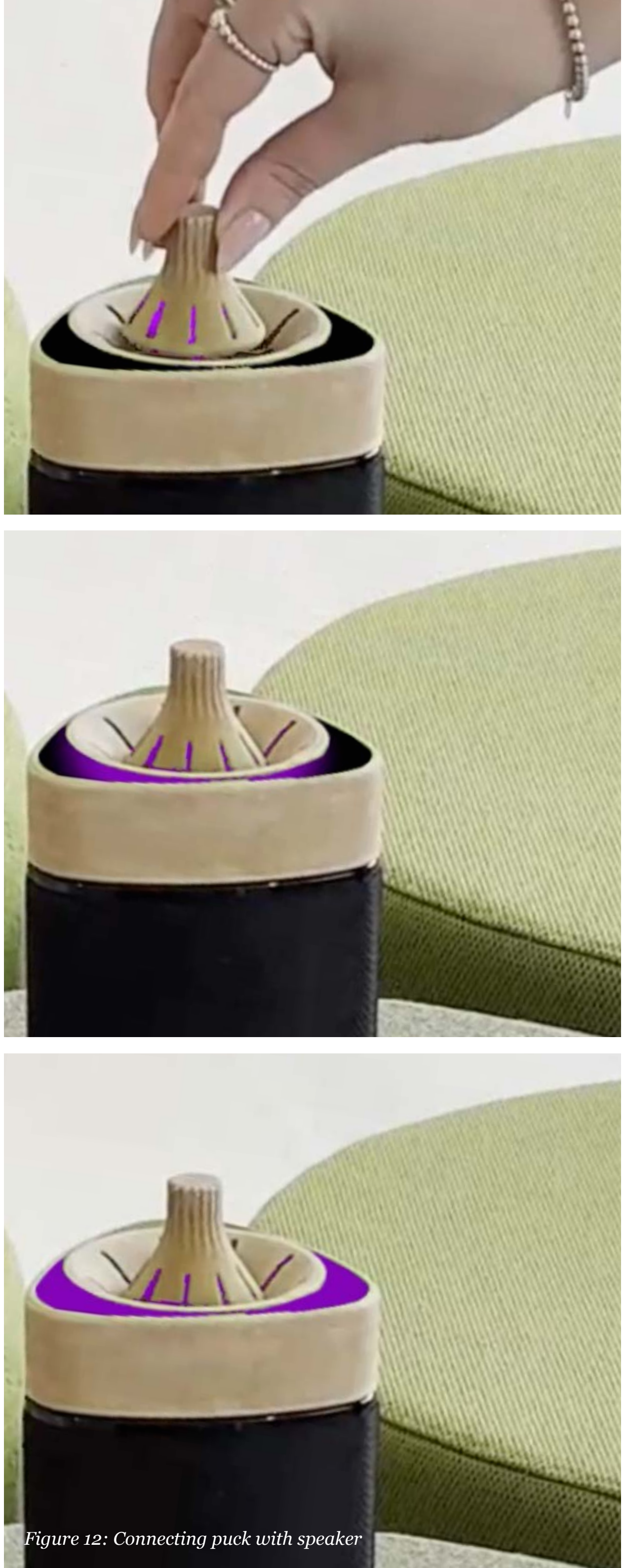


Figure 12: Connecting puck with speaker

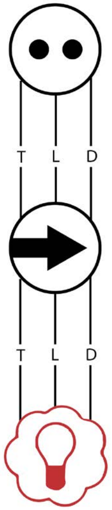


Figure 13: Framework for connecting the pucks

Connecting

When connecting the pucks to each other or to a device, the direction (D) of the action is visualized with the lights on the pucks and devices. When connecting two unused pucks to each other, the lights show a colour emerging from in between (see Figure 11). When connecting a puck to a device or speaker, the colour spreads from the puck into the device (see Figure 12). This way, the interactions have unity of location (L) and time (T), as shown in Figure 13. Connecting the pucks has no unity of expression (E), but this could be improved by, for instance, exploring how the force or speed of placing them affects the speed at which the colour spreads.
To visualize which objects are connected, we use colours. Every puck, device and speaker showing the same colour are connected to each other.

Figure 14: Adjusting font size and line distance

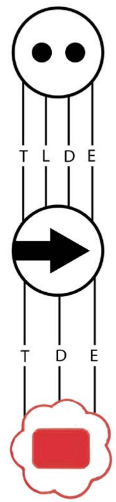


Figure 15: Framework for sliders

Sliders

To control the font size and line distance, we made two sliders on the side of the e-reader (see Figure 14). To increase the font size, you slide the two sliders away from each other to mimic the movement you would make when zooming in on a touchscreen. This way, the user can predict the behaviour of the system because of the likeness of the interaction with a screen that the user already understands. In this case, there is a metaphor match, a direct association between the source and target domain.

To increase the line distance, you move both sliders down together, and the lines on the screen will follow. This interaction has a lower metaphor effectiveness. There is too much dissimilarity between the source and target domain.

The user can get confused because the same sliders are used for two different functionalities, they assume the only function of the slider is the font size. The problem is the combination of two metaphors in one slider, which causes a mismatch in the mapping of the metaphors [12].

After reflecting on the end presentation and the literature about the use of metaphors written by Neale and Carroll [12], the sliders leave some room for improvement. Controlling these entities physically hasn't been that much of an improvement from a screen. The way you should control it is not clear from just looking at it; the location of the sliders is not ergonomic, and it is a preference you don't have to adjust often when you have your personal e-reader; otherwise, connecting it to user profiles would be a better option.

Even though it needs improvement in practice, the interaction meets the framework as can be seen in Figure 15. This interaction contains the unities of time (T), direction (D), and expression (E); The output happens at the same time as the input, the distance and size follow the sliders' movement, and the faster you slide the sliders, the faster the output reacts. The location (L) of the interaction input could be improved; now, the sliders are on the side of the screen, but the changes happen on the screen itself.

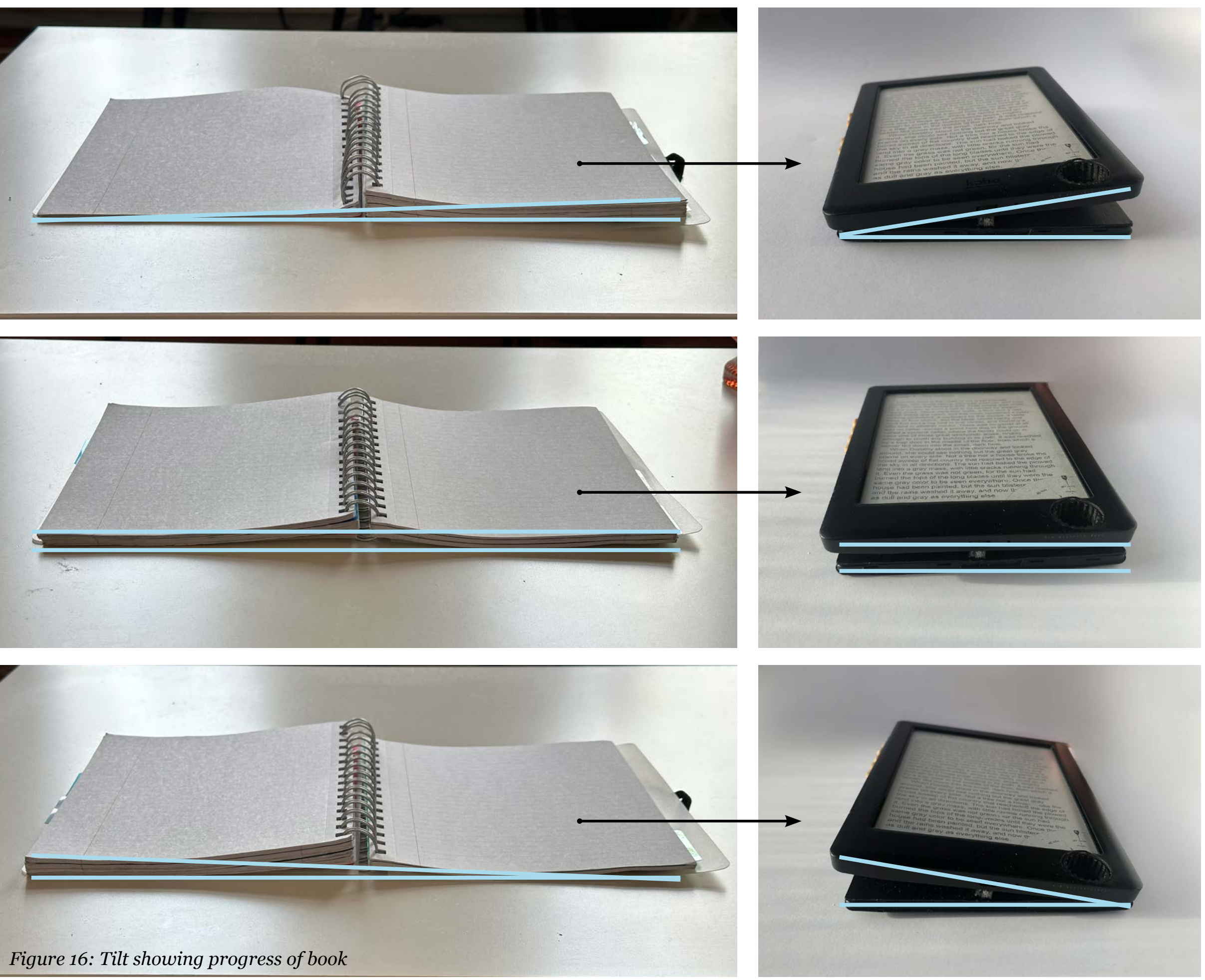


Figure 16: Tilt showing progress of book

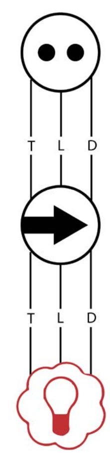


Figure 17: Framework for turning a page

Progress Overview

To mimic the shape of an open book, the e-reader visualizes the progress in the book by tilting the screen. The side that is the thickest is the side with the most "pages". The further you get in the book the thinner the right side gets, as is shown in Figure 16. This way, the reader can still have the experience of progress as with a physical book. An unexpected cliff-hanger will not be a problem anymore, since the user knows the book is nearly finished. For this, we used a framework called "user interface metaphor", which utilizes prior knowledge to help the user understand this new situation by being familiar with it [12].

Turning Page

Instead of a swipe movement on a screen, we chose to physicalize the turning page interaction together with the progress overview. To turn a page, the user tilts the screen towards the side they want to turn to, pressing down the right side will go to the next page. When analysing this interaction with the framework (see Figure 17), the interaction has the unities of time (T), location (L), and direction (D). The interaction does couple the unity of direction because you press the side down which will eventually become thinner with the progress of reading the book.

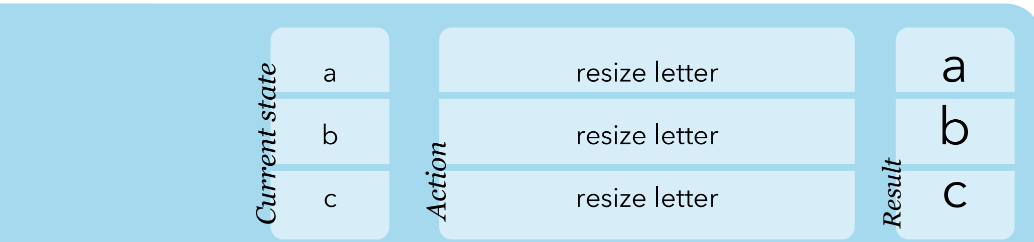


Figure 18a: Direct enlarged letters

Figure 18b: Grouped enlarged letters

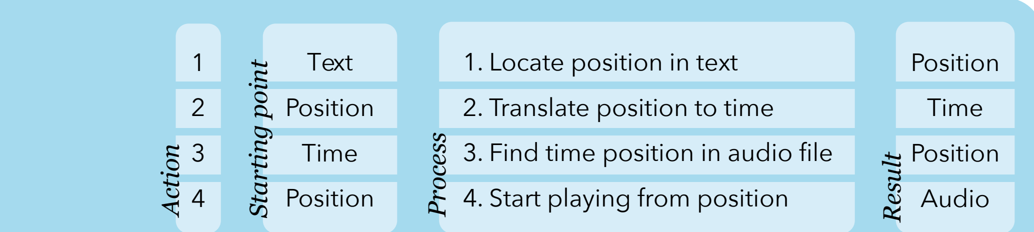


Figure 19a: Direct processes

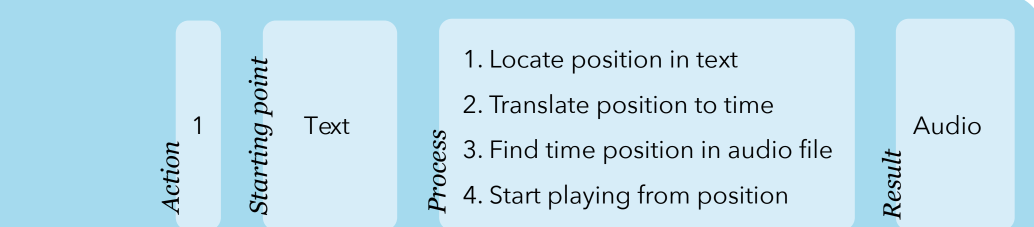


Figure 19b: Grouped processes

Technical parameters and Parameters of use

Various technological parameters in the e-book are automated, such as the transition from e-book to audiobook, visually increasing the size of the letters and line spacing and turning the pages. These processes can all be considered as grouping processes. The microprocessor working in the background does nothing new, but in this form of ubiquitous computing, it makes it so easy to do that it requires no effort for the user to do [15]. The user can control the system parameters through control elements, the parameters of use [4].

When adjusting the font size, not each letter is enlarged separately or directly (Figure 18a), but the complete group of letters is automatically enlarged (Figure 18b). The same process is used for the line spacing. The sliders on the side of the e-reader ensure that the user can set these parameters in a controlled manner.

Another form of grouping process is the transition from an e-reader to an audiobook. The underlying processes ensure that the e-reader part indicates where it left off in the book and passes that point onto the audio function. This section locates this same point in the audio clip and begins playing from there (Figure 19a). This group of functions is internally automated and is indicated (controlled) when the user places the puck in the e-reader (Figure 19b). In addition to this group, the sleeper function can be seen where the remaining play time is set by rotating the puck while it is automated and displayed on the screen.
The other parameters of use with a more elaborate functionality on the background are the connecting of the pucks, setting the volume by rotating the puck on the speaker and turning the pages by squeezing on the side of the e-reader.

With these above examples, we want to show on one hand that we want to reduce the overload of information through ubiquitous computing [15], but not only that because at the same time, we want to give the user the feeling of control through intuitive interfaces [13]. This way the user can enjoy the system the way he wants to enjoy it, according to his needs and without having to worry about the underlying actions of the system.

Core and emergent functionality

The system of the connected speakers should be allowed for growth. To do so, we used the system of growth according to Frens et al. [3, 6] with regards to the use of systems with their separate core functionality and the relation of these core functionalities. This ability to grow gives the overall system an extra, emergent, functionality that can exist because the core functionalities are available.

The first core functionality, sound, was chosen from a convenience approach. Convenience because it releases you from the struggle to connect your media devices to a sound system. It is a separate speaker which is available to control [3] by a puck. This puck can connect the speaker to your input device, which can change the volume. The second core functionality, which is related to an e-reader, is displaying the text of a physically chosen e-book. Displaying the following pages can be actuated by squeezing the e-reader to the side you want to book to progress.

The emergent functionality is an audiobook, it emerges between the two core functionalities and is neither part of the speaker nor the e-reader [3]. The system needs both core functionalities to act as an audiobook, it needs the text from the e-book in the e-reader and the sound can only be played by the speaker. This emergent functionality is activated by connecting one puck to the e-reader and one puck to the speaker.

It could be argued that an e-book does not seem to have a relation to sound at first, however, text-to-speech technology easily relates the text of an e-book to speech. We acknowledge that it is an abstract representation on a system level of the functionality of the system and it is the modus operandi of software [6] to make this possible. This makes it also directly related to the technical parameters which are grouped with the parameters of use of connecting the e-reader with the speaker by using both pucks.

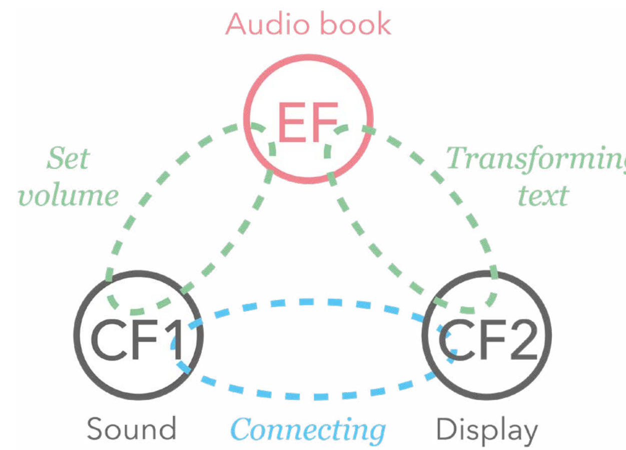


Figure 20: Core and emergent functionalities

The e-reader is a component that could stand on its own and could therefore be well part of a hierarchical system [14]. The speaker is also a component on its own because it plays sound, but it seems to get more added value by transcribing the data of the audiobook into spoken word. It operates simultaneously with the e-reader to achieve the desired functionality. The relation between the audiobook and the speaker is not directly the sound, but the possibility to control the volume to a level that allows you to move and act in the house and still listen to the audiobook.

By using the pucks to connect the e-reader and the speaker, meaningful audio and volume control are combined to a meaningful relationship creating an audiobook function.

Centralized / Distributed control

Control over IoT systems can be offered in a centralized or distributed manner, or both. We define centralized control as multiple IoT devices being controlled centrally in one place. These can be multiple instances of the same device, or multiple different devices altogether. This approach can have certain benefits, such as efficiency for the user by not having to physically move towards a certain device to control it. Another potential benefit of centralized control is that it might result in unique emergent functionalities that could only emerge by having all controls in one place. A possible disadvantage of exclusively using centralized control is that devices without individual controls can become useless when their control element stops working.

We believe that to create reliable and futureproof IoT systems, devices should always be able to be controlled individually without relying on connections to other devices. This is a large benefit of distributed control, which we define as IoT devices having on-device controls for their own functionality. As stated by McCarthy [11], industrial processes that rely on each other are better to be controlled by centralized control systems, whereas independent processes are more reliable when controlled by distributed control systems [11]. This point could be extended to IoT devices, which are usually able to operate independently. Another major benefit of distributed control becomes clear when aiming to design for rich interaction. According to Frens [4], this requires integrating form, interaction and function and the relationships between them. We believe that inherently, distributed control helps build a stronger relationship between the interaction and the function since the function is something that happens on the very device currently being interacted with by the user. Centralized control would create a physical distance between the interaction and the function, creating a need for additional feedback.

In our design process, we emphasized distributed control because of the benefits it brings to rich interaction. For instance, our design concept allows for changing the volume by rotating the puck on top of the speaker. We intentionally did not want to change the volume remotely, since it affects the amount of sound coming out of the speaker. Controls related to the audiobook, such as setting the timer, happen physically on the e-reader. However, besides distributed control, the unique benefits of centralized control make it a worthwhile effort to include as well. In our case, it could make sense to allow changing the volume from a different or centralized location since it might not always be convenient to have to walk to the speaker to change the volume. For IoT, offering a combination of both distributed and centralized control is a very realistic opportunity to offer the best of both worlds.

Approaches towards growth

When designing the second core functionality (the rich interaction e-reader) and afterwards designing for the emergent functionality, we noticed that we could leave our first core functionality (connecting speakers tangibly) pretty much as is. It made sense: Connecting the e-reader to a speaker results in the emergent functionality of an audiobook, after which we designed rich interactions to use the audiobook. At first, we assumed we would have to adapt our first core functionality to enable the emergent functionality, so not making any changes to it felt like a wrong decision at first. However, when looking back we see that this actually means our first core functionality was already well made and open for growth, so we analysed it more in-depth to find out what made it so “good”.

Van Campenhout et al. [2] defined three types of tangibles: (1) Containers are dynamic but generic, any type of digital information can be coupled and decoupled, they do not physically reflect the nature of the digital information; (2) Tokens are iconic but static, they are permanently tied to the digital information it represents and reflects the information in its physical properties; and (3) Clusters are both dynamic and iconic, physically reflecting the functionalities while not being permanently tied to the digital information it represents [2]. The pucks we used in our first core functionality, are a cluster. They physically represent the functionality of creating a connection but are not permanently tied to only one connection. They only carry the meaning / digital information given to them by the user, making them dynamic; but can only be associated with one specific type of information (namely a connection), making them iconic.

The dynamic and open nature of this type of tangible allowed it to be implemented directly in assignment 4 without having to change the concept. In their case study, Van Campenhout et al. [2] used multiple clusters as modules in their design, each embodying a different product functionality. In a way, a cluster can always be considered as one module in a modular device, which is one of the four approaches to growth as defined by Frens [5]. We used the modular approach for the majority of our interactions, like using the pucks to connect a speaker to a device, but also for the book tokens and the way the puck provides additional rotary controls. For one functionality, setting when to stop reading, we made use of the hybrid approach, where the information being manipulated by the interaction is shown on the screen. This mix of approaches leads us to believe that a device or system does not need to make use of one approach exclusively, but instead that one approach can be chosen per function. We used the modular approach for the functions of choosing a book and connecting to a speaker but used the hybrid approach for the function of setting a timer. For IoT devices and systems to be open to growth, they need to be made future-proof. This means that they should not rely on external servers, and should be interoperable using standard communication protocols [9, 10]. This interoperability also needs to be understood by the user. Based on our experiences, we believe that besides making individual devices more intuitive, rich interaction has the opportunity to make the interoperability understandable to the user. Without having realized this yet, this is what we did in assignment 3. We conceptualized a hypothetical interoperable system of speakers and audio sources all capable of working together and designed an interaction to help understand and make use of this interoperability. However, this is only about the specific use case of speakers, although a similar concept could be used to visualize a connection between other types of devices. It will likely remain a challenge how to use rich interaction to explain interoperability, but based on our experiences using the modular/hybrid approach, we believe it is possible. At least among a smaller and specific subset of devices.

Figure 21: Prototype of the book tokens

Book tokens

In the design of the e-reader, we choose to use physical tokens for books, see Figure 21, inspired by the tokens as defined by Van Campenhout et al. [2] which are a permanent representation of the digital information they represent [2]. Our book token has a rectangular shape, on which you can see the cover of the book. We chose to use a physical representation of the book rather than a digital library for a variety of reasons after considering both options.

Primarily, we wanted to maintain the qualities of physical books in the e-reader. Therefore, we started to research why some people prefer a physical book over an e-reader. This has multiple reasons, such as the feeling of ownership [7, 8], visibility [8] and shareability [16].

The feeling of ownership

Studies have shown that people tend to see digital objects as “not real” and therefore less valuable than physical objects [7, 8]. We tend to see digital objects as short-term objects that can be quickly replaced and they are not reliable because of outside factors, such as updates [7, 8]. The purpose of the token is to enhance the feeling of ownership of the digital books.

Visibility

In interviews conducted by Gruning [8], participants mentioned that they sometimes buy an e-book and a physical book at the same time. The e-book is for reading and the physical book is for displaying in their home [8]. People mentioned that the physical form helps to remind them of the existence of the book but also the memories of that time when reading that book or to show part of their identity [8]. With e-books, people didn’t have this external visibility, which negatively impacted their functionality for these kinds of identity-related purposes [8]. The token plays into this visibility, by showing clearly which book each token is and you can store it so that you have a collection of all the books you have read.

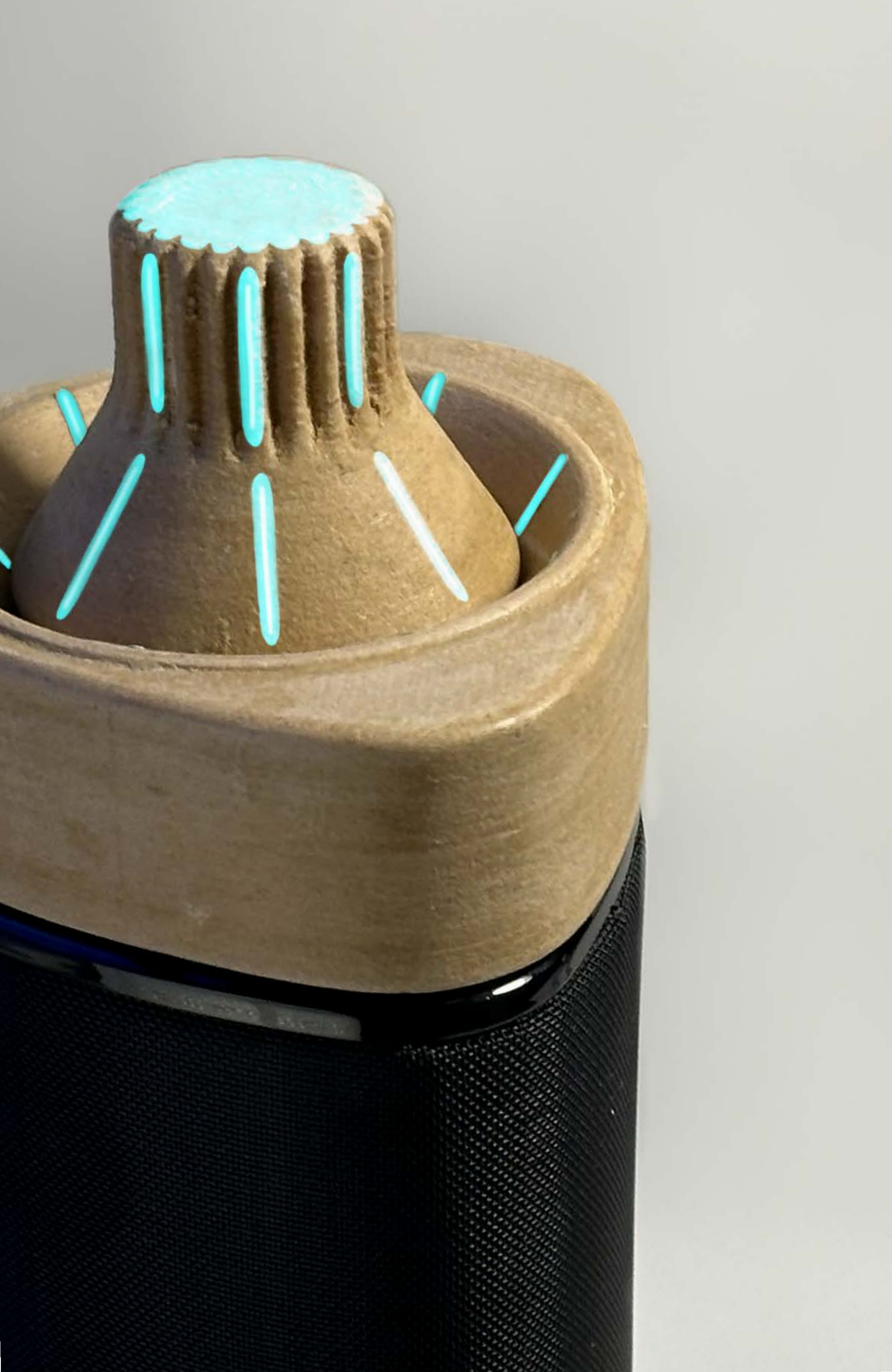
Shareability

70.3% of the people indicated that they prefer physical books over e-books when it comes to sharing [16]. They dislike sharing e-books because of DRM restrictions [8], which make it almost impossible to share books legally. The book token plays into this need, when the token is bought, you can easily share it with others, like you used to do with physical books. You don’t have problems with the DRM rights, because the token is physical.

Feasibility

The concepts of connectivity and the physically chosen e-books are easy to understand and even the emergent functionality of the audiobook is tangible. This makes the system, or the separate parts, worth further investigating for feasibility in the market. Not everyone agreed but the mainly positive reactions during the final presentation from peers and experts substantiate this claim. However, it was also mentioned that some adjustments will be inevitable to make it economically feasible.

The technology of physically choosing an e-book is not new and therefore technically feasible. Our detailed technical knowledge of Bluetooth, Wi-Fi or alternative connectivities is too low to make a substantiated statement about this feasibility. However, the single function of connectivity of this system should give the system an advantage over the other systems that have multiple functions.



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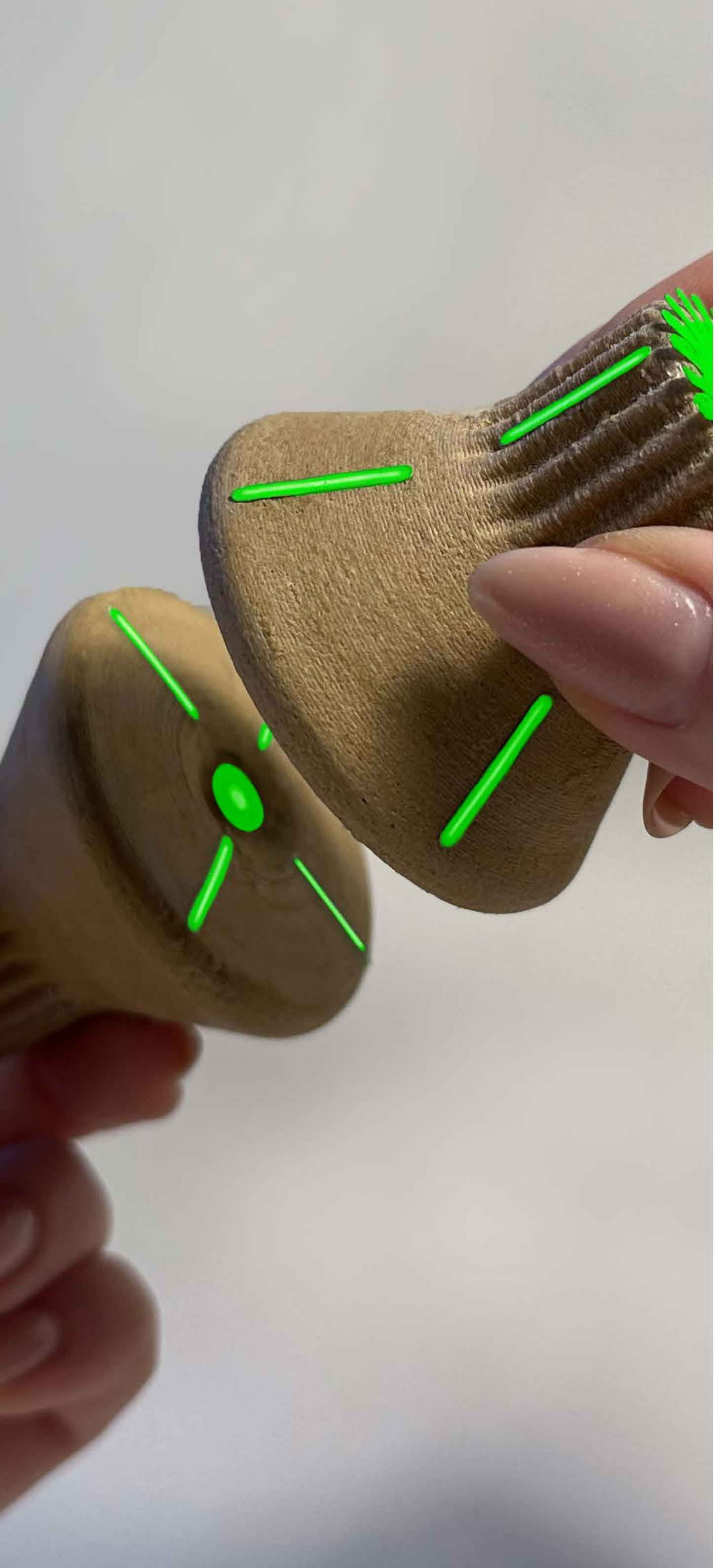

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