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Part A: Literature Discussion

Summary and discussion of paper 1

In the paper “Emerging Frameworks for Tangible User Interfaces” Brygg Ullmer and Hiroshi Ishii share their thoughts on tangible user interfaces (TUIs), introduce an interaction model for TUIs, and illustrate their framework with examples.

The authors aim to identify a recognizable and unified stream of research on TUIs and therefore include many examples, which they cluster into five application domains. Two examples are explained in more detail. The first is called “URP” and is used to model urban planning. The second is called “MediaBlocks” and comprises blocks that are dynamically linked to online media elements, similar to a physical URL [1]. With the example of URP they illustrate that “tangible interfaces give physical form to digital information” [1, p. 2]. That means that physical artifacts act both as representations and controls for media and are coupled with digital representations [1]. In contrast to graphical user interfaces (GUIs), in TUIs physical objects indicate and control the state of the user interface [1].

Central to the paper is the distinction between digital and physical representation. Physical representation is defined as information physically embodied in the concrete tangible form [1]. Digital representation is defined as computationally mediated displays perceptually observed but not physically embodied [1].

The interaction model introduced is based on the “model-view-controller” (MVC), an interaction model created for GUIs that visualizes the relationship between input and output [1]. According to the authors, the MVC underlines the separation of digital and physical representation. Therefore Ullmer and Hiroshi introduce their model “model-control-representation (physical and digital)” (MCRpd) that divides the MVC’s element “view” into the previously defined physical and digital representations. Through this, they aim to highlight the integration of physical representation and control [1].

The key characteristics of TUIs that the MCRpd highlights are described as follows: [1, p. 4]

1. Physical representation (rep-p) coupled to underlying information (model)
2. Physical representations embody mechanisms for interactive control (control)
3. Physical representations perceptually coupled to actively mediated digital representations (rep-d)
4. The physical state of interface artifacts partially embodies the digital state of the system.

The use of examples in the paper is helpful as it illustrates the authors’ points and makes them easier to grasp. What is more, the examples used are clustered into application domains, which gives a great overview of existing works and allows us to classify them. By including and

clustering many works, the authors seem to achieve their goal of finding a distinct and coherent research stream for TUIs.

Not mentioned in the paper, however, is how the newly introduced interaction model MCRpd is supposed to be applied in practice. The authors describe the model but do not impart the application and the value added by applying it. By exploring the model in application, valuable insights into the limitations and opportunities of the model could be discovered.

Summary and discussion of paper 2

The paper “Tangible products – Redressing the balance between appearance and action” by Djajadiningrat et al. focuses on interaction design for electronic products and so-called “form-giving,” which is defined as the “way in which objects appeal to our senses and motor skills” [2, p. 294].

The authors argue that today’s consumer electronics primarily resemble interactions with a PC. Therefore, the goal of their research was to find more suitable interaction styles for electronic products and to bridge industrial and interaction design [2].

Electronic product controls and actions often lack differentiation and rely heavily on icons [2]. This is a result of what the authors describe as the semantic approach. This approach communicates the functionality through reference by using metaphors and comparing new to existing products [2]. The authors add that in the semantic approach symbols and signs like icons are often used. To avoid having to read and interpret icons and labels and design controls that communicate their purpose through their form, the direct approach is introduced. The direct approach puts high value on perceptual and bodily skills and tries to create meaning in the interaction [2]. The authors argue that this approach offers more room for expressiveness.

Another distinction is made between the data-centered and perceptual-motor-centered approaches. In the data-centred approach, objects carry or manipulate segments of data, often resulting in designs consisting of several objects [2]. The perceptual-motor-centered approach on the other side puts focus on differentiation in appearance and action and aims to explore how physical objects can invite actions of users [2].

To back their view on tangible products the authors describe five projects, one student exercise, and four prototypes that explore new interaction concepts for existing products. One of the prototypes, “video deck,” focused on the form-giving of the controls of a video player and showcased the necessity for differentiation in appearance and action [2]. Another prototype aimed to reinvent the interaction with a digital camera by using forms to couple and decouple components and create meaningful relationships between appearance, action, and function [2].

The paper includes five examples that illustrate and back the points made by the authors. The described learnings from each project are insightful and demonstrate the authors' profound understanding and expertise.

The views expressed in this paper are very critical of GUIs and portray them in a rather negative light. This view might be appropriate for some use cases, but this generalized negative view does not seem well grounded. In contrast, the approaches introduced in the paper like the perceptual-motor-centred approach for instance are shown in an overly positive light and seem to lack critical discussion. To give a balanced picture, a more critical reflection of the proposed approaches and projects could be helpful.

Part B: Prototype

Step 1

First, we brainstormed ten ideas for a tangible user interface that could be used for our video prototype. The following section outlines the ten ideas.

Idea 1: Soft Toy

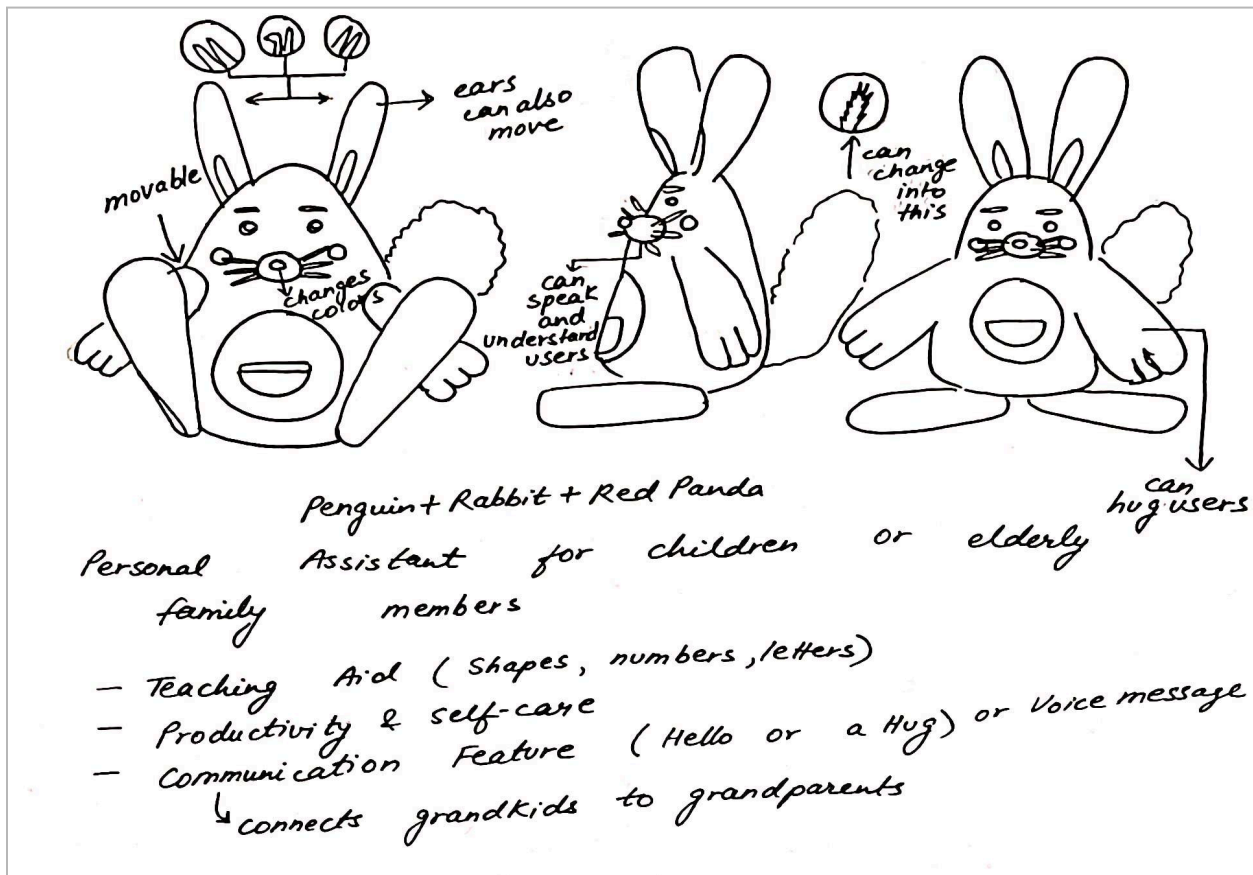


Fig 1. Product Idea 1 "Soft toy that heals you(mentally)"

A plush toy [Fig.1] designed to keep loved ones close, especially children and grandparents. It can send virtual hugs, exchange voice messages, and even assist with educational activities like teaching basic concepts through playful interaction.

Idea 2: Smart Shower dispenser

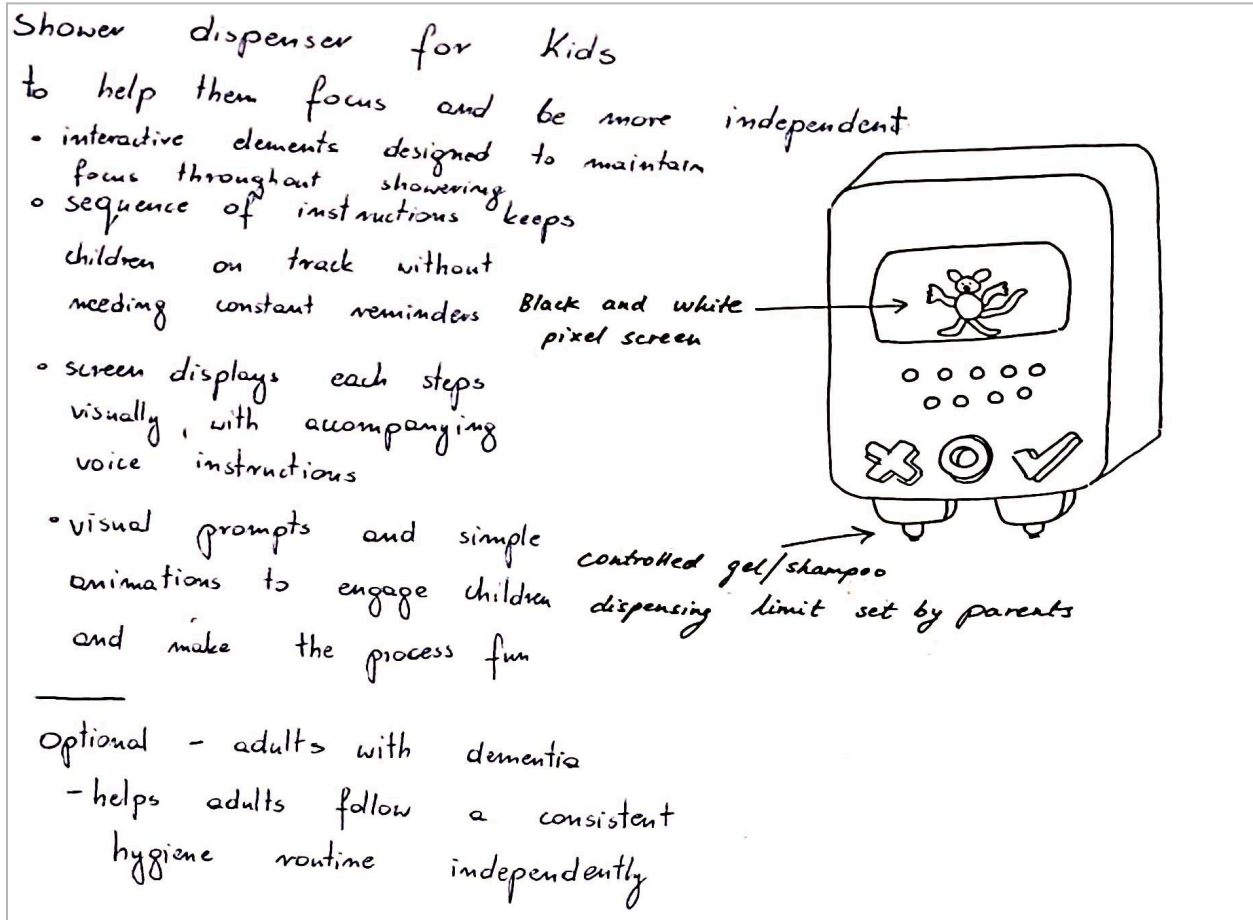


Fig 2. Product Idea 2 "Smart Shower Dispenser for kids with animation"

A Smart Shower Dispenser [Fig.2] that uses fun animations and characters to make bath time exciting for kids. It encourages proper hygiene habits through interactive feedback.

Idea 3: Cooking assistant

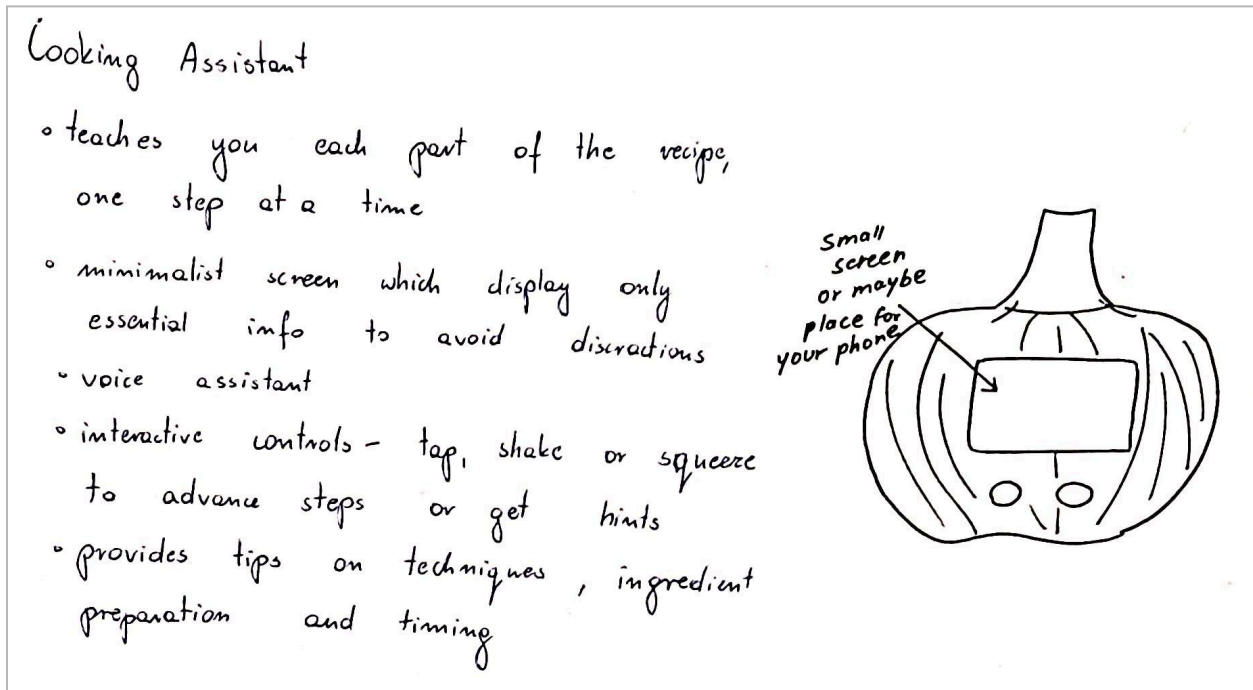


Fig 3. Product Idea 3 "Cooking Assistant for easily distracted home cooks"

A kitchen gadget [Fig.3] that helps home cooks stay on track by guiding them through recipes step-by-step and reminding them of critical tasks like stirring or checking the oven.

Idea 4: Smart Salt Lamp

Lamp - break reminder

- styled like a salt lamp for a calming, natural aesthetic
- different light colors:
 - warm light - work mode
 - soft blue light - reminder to take a short break or stretch
 - green light - relaxation time
- periodic sounds to remind users to take a break from the screen
- shake for customizable functions
eg. break timer reset or mode change
- squeezable surface that provides a stress relieving hand massage

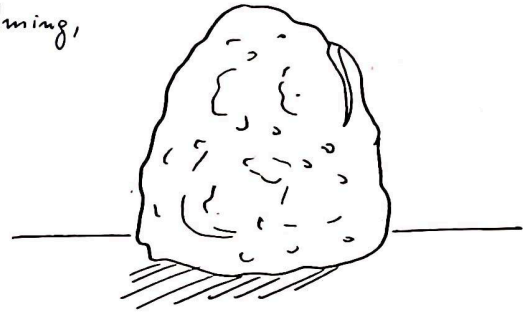


Fig 4. Product Idea 4 "Smart Salt lamp that enhances your mood"

A stylish salt lamp [Fig.4] that creates a calming ambiance by changing colors and playing soothing sounds, designed to improve the user's mood and relaxation.

Idea 5: Dancing Tumbler

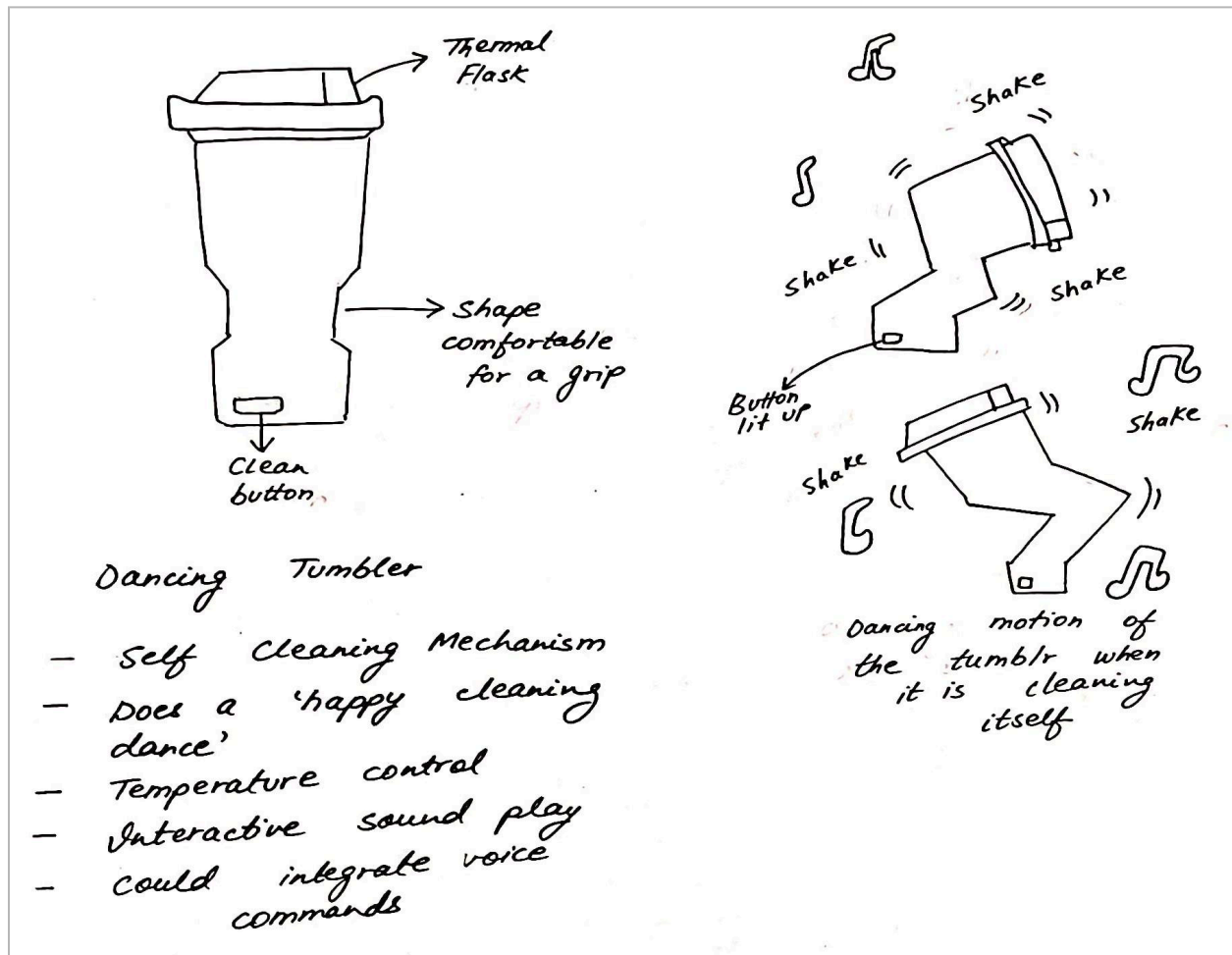


Fig 5. Product Idea 5 "The self-cleaning Tumbler that dances"

A reusable tumbler [Fig.5] that cleans itself after use and performs entertaining dance moves, bringing fun and convenience to your daily routine.

Idea 6: Smart EarBud

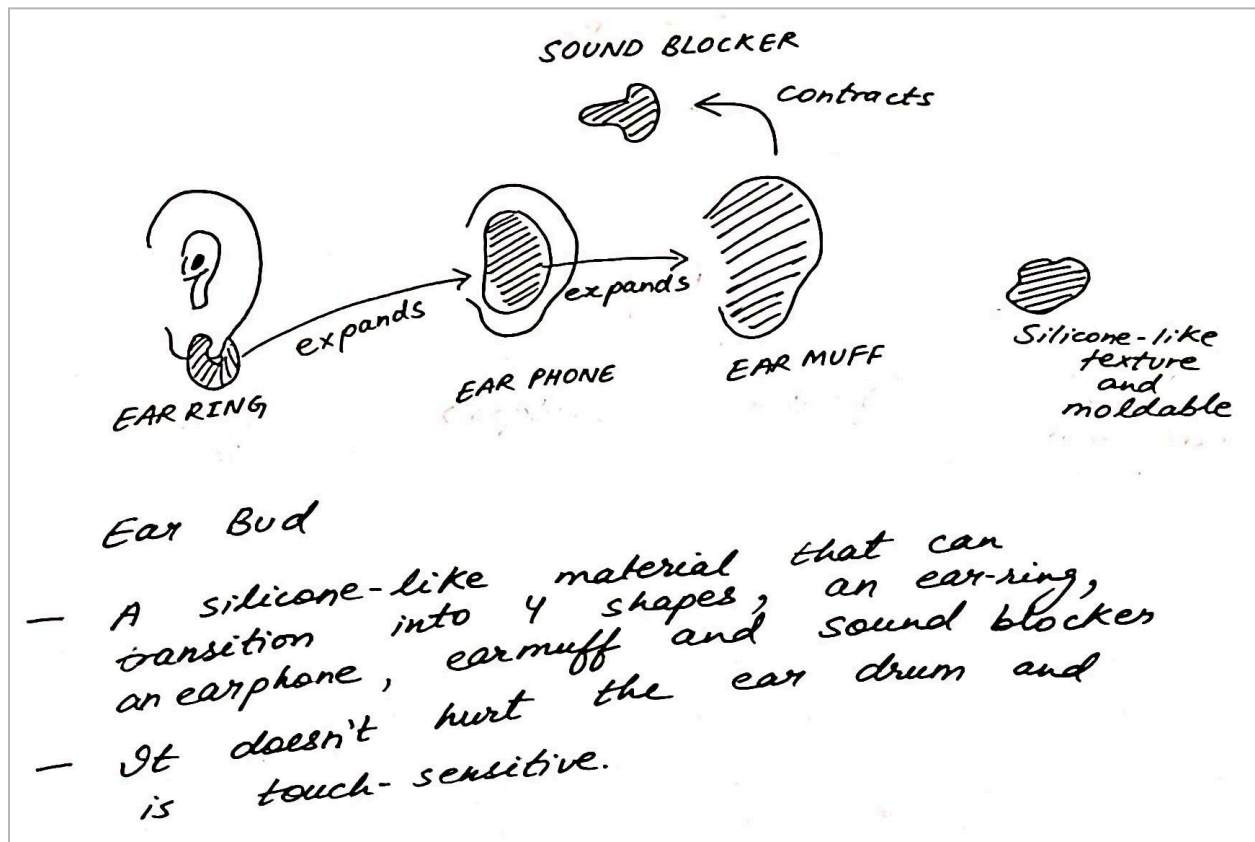


Fig 6. Product Idea 6 "Smart EarBud that can transform into four different forms"

An earbud [Fig.6] is made from materials that adapt to the shape of your ear, ensuring maximum comfort. It can also transform into different forms, such as earrings or earmuffs, depending on the user's needs.

Idea 7: Super Smart Key

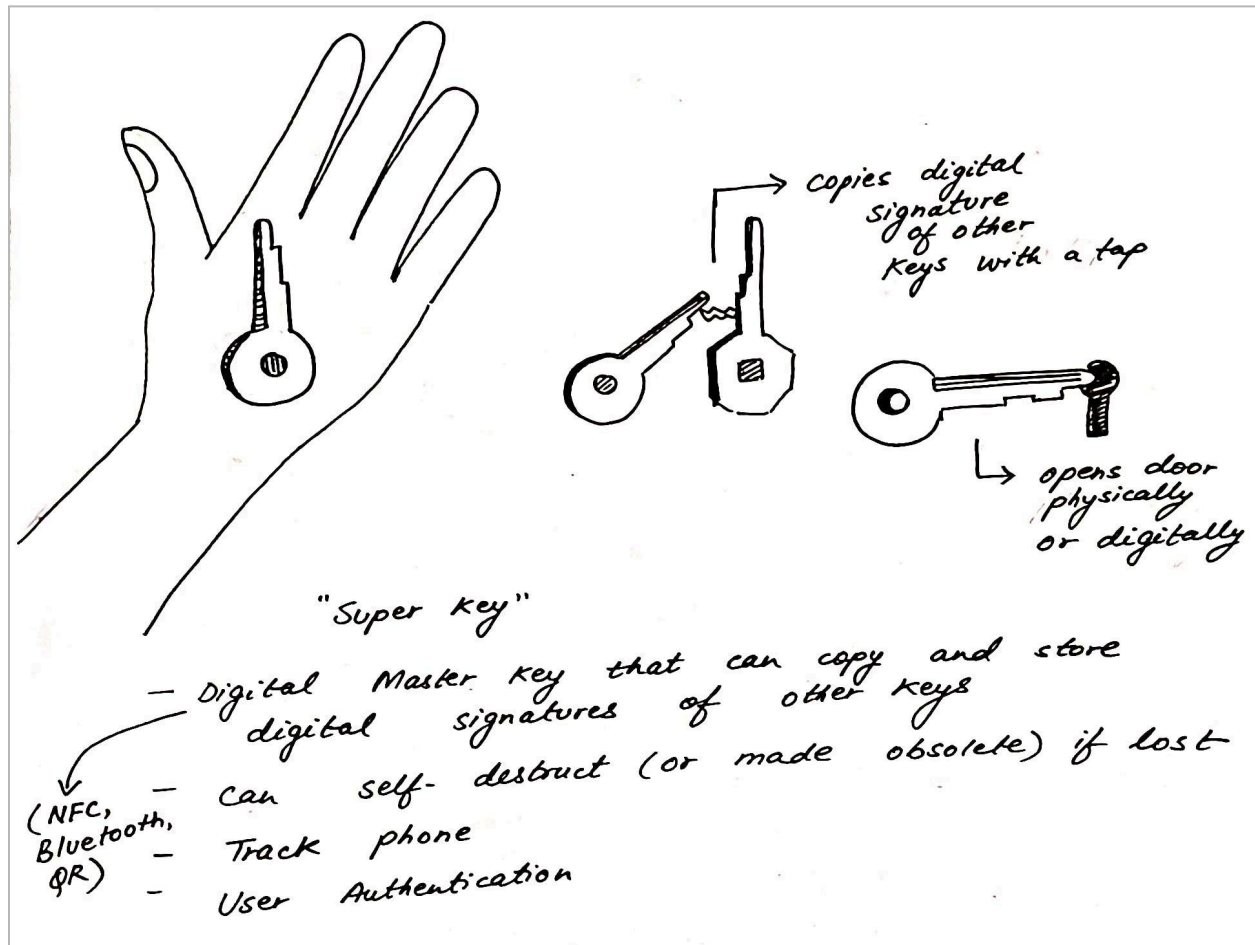


Fig 7. Product Idea 7 "Super Smart Key"

A high-tech key [Fig.7] that can store and recognize used locks, offering enhanced security and peace of mind. It also alerts you if it's forgotten or misplaced.

Idea 8: Luminous Smart Clay

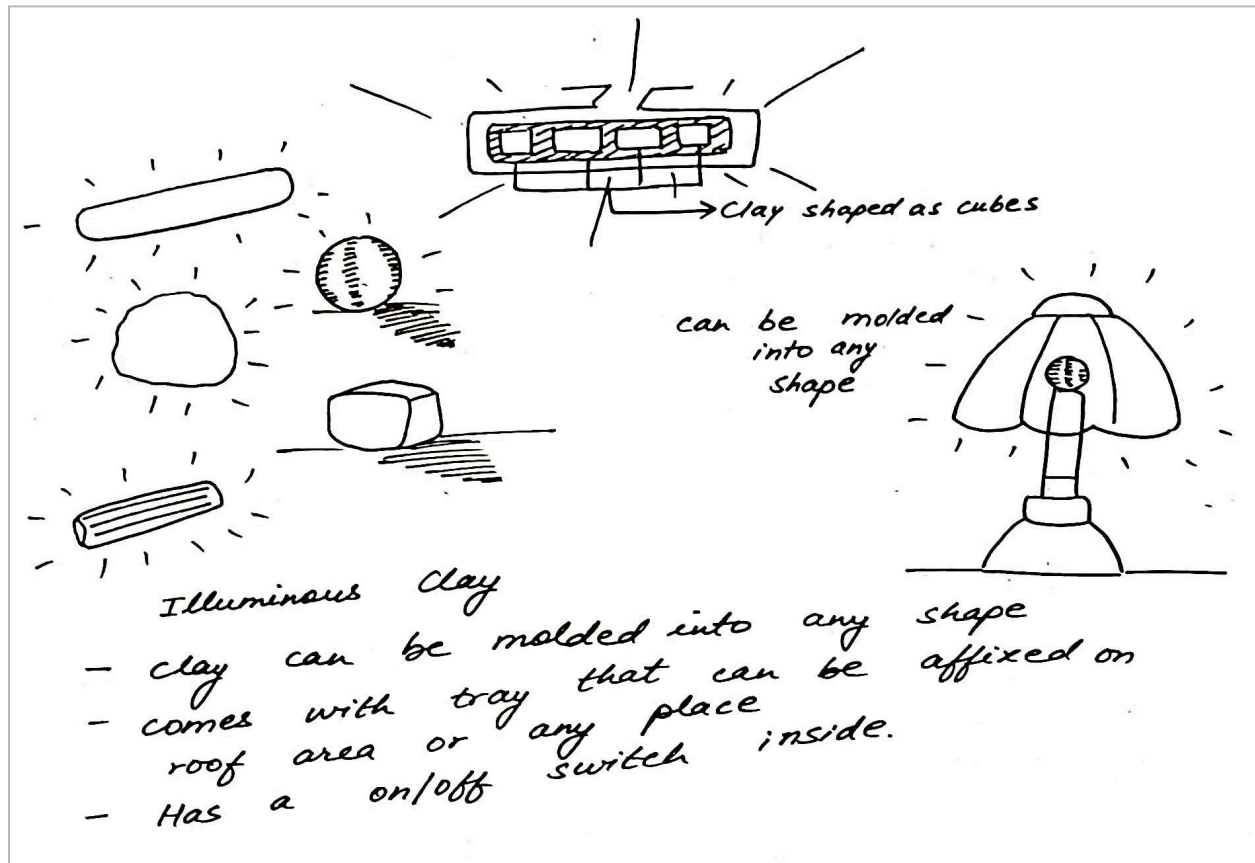


Fig 8. Product Idea 8 "Illuminous Smart Clay that can be used as a substitute for a light source"

A creative and flexible light source in the form of glowing clay [Fig.8] that you can shape and mold to fit any environment or decorative idea.

Idea 9: Smart blanket

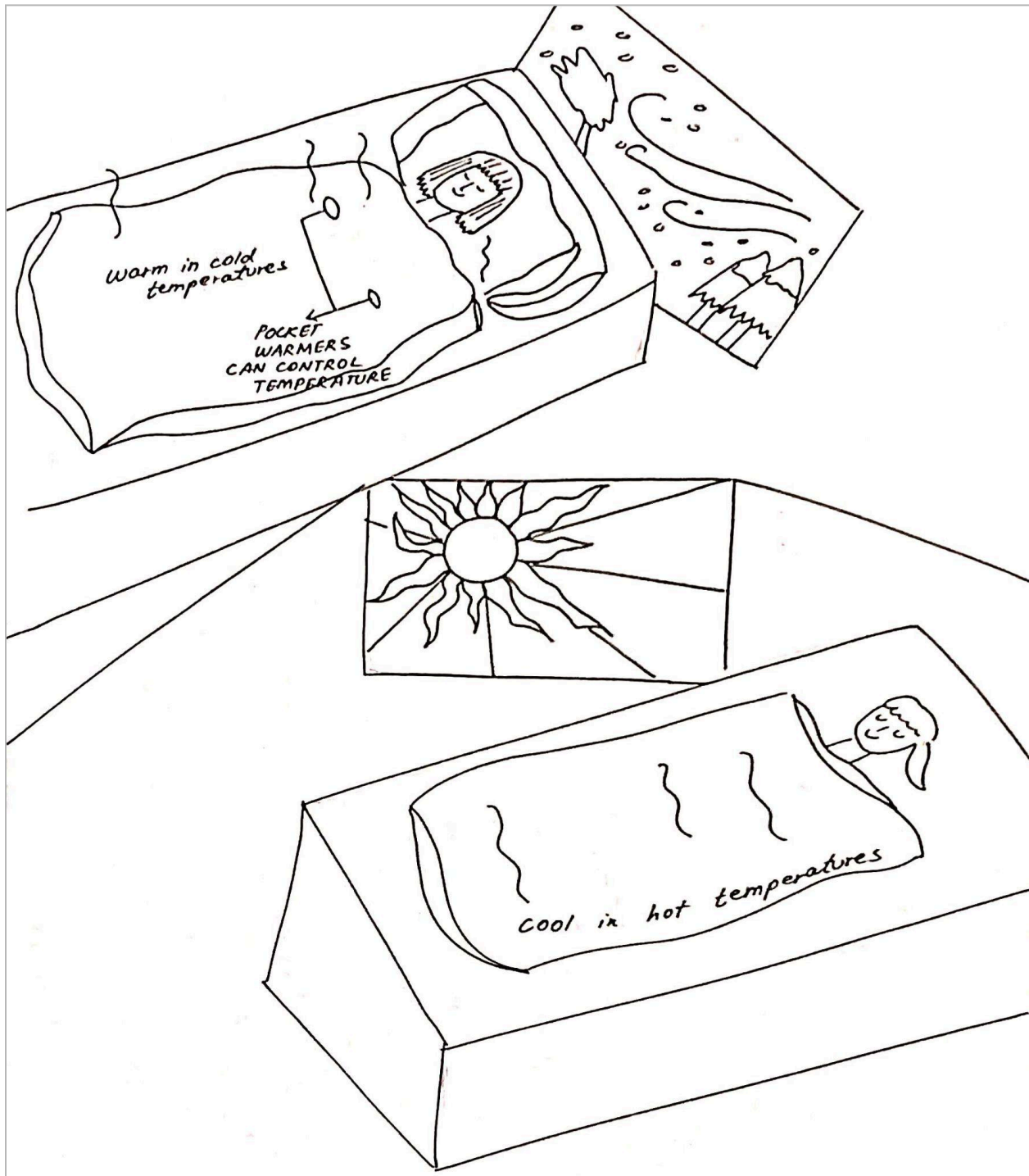


Fig 9. Product Idea 9 "Smart blanket that cools you in summers and warms you up in winters"

A cozy blanket [Fig.9] that adjusts to keep you cool during hot summers and warm in the cold winters, ensuring perfect comfort throughout the year.

Idea 10: Story generator for kids

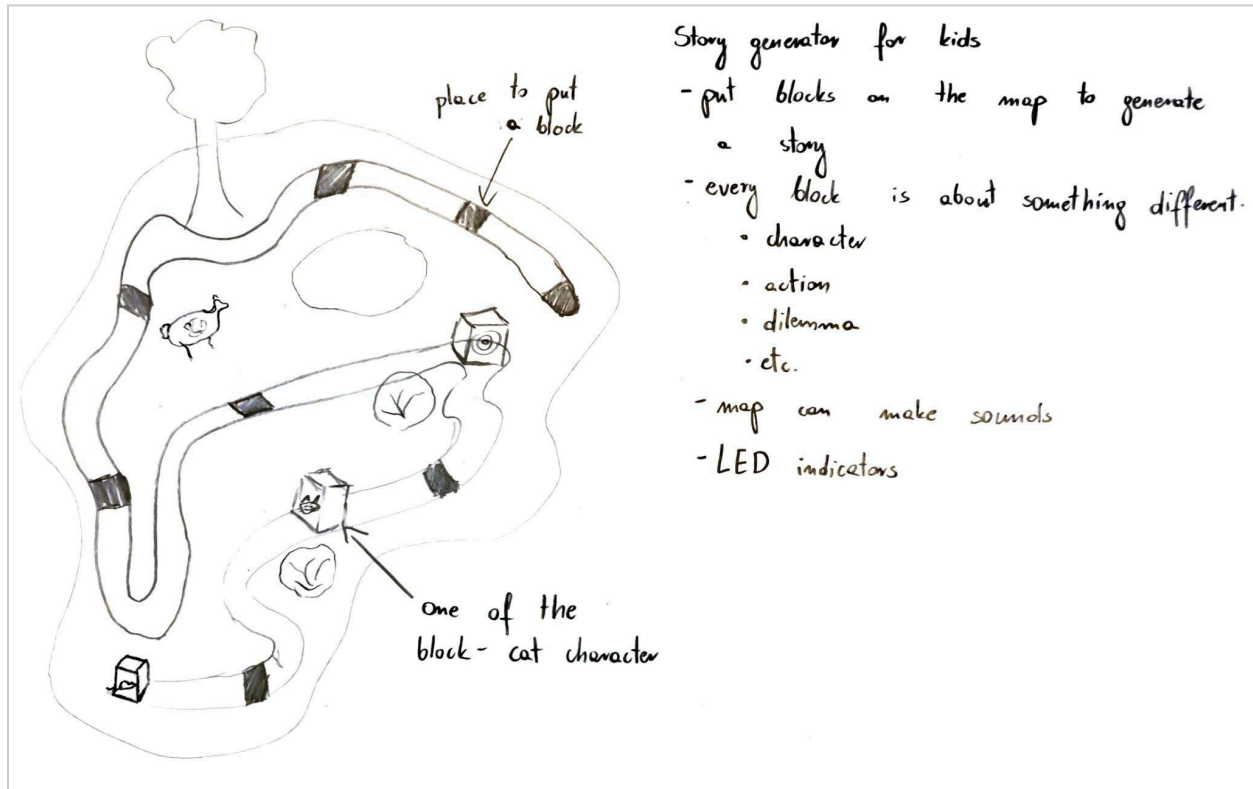


Fig 10. Product Idea 10 "Story generator for kids"

A map [Fig.10] that creates personalized and engaging stories for children, sparking creativity and making storytelling interactive and fun.

Step 2

After brainstorming our ideas, we decided to focus on two concepts: the Soft Toy and the Smart Shower Dispenser. These ideas felt the most practical and exciting to work on.

The Soft Toy was a favorite because it's not just a toy—it helps loved ones, like kids and grandparents, stay connected by sending virtual hugs and voice messages. It can also teach kids through fun, interactive activities. We saw a lot of potential to make it creative and functional.

The Smart Shower Dispenser caught our attention with its fun approach to hygiene. With animations and playful feedback, it turns bath time into an enjoyable experience while encouraging good habits.

We didn't choose some of the other ideas because they were too simple or didn't offer much for people to interact with. Some ideas were too complicated to build in the time we had. Overall, the ideas we picked felt more fun and easier to work on.

In the end, we chose the Soft Toy for our video prototype because we all found it the most interesting. It's something that combines emotions, learning, and fun in a way that feels really special.

Idea 1: Soft Toy

The Soft Toy offers a unique combination of emotional connection and interactive features. It could use touch sensors in the hands and ears to trigger actions like sending virtual hugs or voice messages. For example, squishing the ear could send a message, while squeezing the hands could activate a comforting hug-like vibration. The toy could also play music or stories through small speakers, offering both entertainment and comfort. LED lights in the eyes would show the toy's status, indicating when it's ready to send a message or play content. Its outer material would be plush and soft, creating a comforting feel, while the electronic components would be safely embedded inside.

The toy would also incorporate signifiers to enhance interaction:

- Ears: The ears could move up and down to provide feedback, indicating when the toy receives a command or hears a user's voice. A small LED strip at the base of the ears could change color to show the toy's current mode, such as green for "listening," red for "mute," or blue for "teaching mode."
- Eyes: The eyes could light up in different shapes to express emotions, like hearts for happiness, question marks for confusion, or crescents for "sleeping mode." They could also blink or flash to show when the toy is processing a command or waiting for input.

- Nose: The nose could serve as a touch-activated feature, such as activating a communication function like sending a "hug" message to a connected relative. It could also double as a voice input trigger, acting as a microphone button for recording or listening to voice commands.
- Hands: The hands could include sensors that activate when squeezed, triggering specific actions like saying "Hello!" or teaching shapes/numbers. The toy could only hug when both hands were squeezed simultaneously, encouraging deliberate interaction.
- Tail: The tail could function as an on/off toggle or act as a gentle pull-on switch to turn the toy on or off. Tugging the tail could also transition the toy into "sleep mode," dimming its lights and playing calming sounds to help the child relax.

Idea 2: Smart Shower Dispenser

The Smart Shower Dispenser is designed for kids, particularly those with ADHD, in mind to make bath time more engaging and help them stay focused. In addition to touch-sensitive buttons for dispensing soap or shampoo, it includes an interactive water mill feature that adds a tactile element to the experience. Kids can spin the water mill by hand, which activates the dispenser and keeps them engaged. This spinning action could also trigger fun sounds, lights, or animations on a nearby screen to provide inherent feedback.

The water mill could have different functions based on how it's used. For example, spinning the mill faster or slower could control the water flow, adding an element of choice and control. It could also be part of a game where the child needs to spin it a certain number of times before the dispenser releases soap, helping them focus and making bath time feel like an exciting challenge. Additionally, the water mill could splash a small amount of water onto the child's hands as it spins, offering a sensory experience that keeps them engaged.

Both concepts offer strong interaction possibilities. The Soft Toy offers emotional connection, storytelling, and educational value, while the Smart Shower Dispenser combines functionality with playful engagement, making it especially beneficial for kids with ADHD.

These ideas are both feasible and exciting, providing great potential for development. After giving it some thought, we figured out that the Smart Shower Dispenser needs a lot more research and development due to its complexity. For this reason, we decided to focus on the Soft Toy, which is more feasible to develop in the time frame and allows us to explore a rich range of interactive features without the same technical hurdles.



Fig 12. Crafting the prototype as a team



Fig 13. Sewing the prototype



Fig 14 & 15. Final prototype (L) Bluey Charging State (R) Bluey with a tutu variation

Status of Technologies:

The majority of the functionalities showcased in the video, including the ability to record and playback messages, gesture-based controls, and wireless charging, are achievable with current technological capabilities. Nevertheless, certain features, like real-time voice message transmission and accurate gesture recognition for belly tracing, may necessitate sophisticated software integration and precise sensor calibration, both of which are still in development within consumer applications.

System Components:

If created in reality, Bluey would involve the following key technologies:

1. **Input Sensors:** Capacitive touch or pressure sensors in the ears, cheeks, nose, belly, and legs for interaction detection.
2. **Actuators:** Servo motors for ear movement and standing upright, and mechanisms for haptic feedback (e.g., belly lighting up).
3. **Audio Components:** A high-quality microphone and speaker for recording and playing voice messages, stories, and songs.
4. **Wireless Communication:** Bluetooth or Wi-Fi modules to enable message exchange between paired devices.
5. **Memory and Storage:** Internal memory to store up to five songs, ten stories, and saved voice messages.
6. **Battery and Charging:** A rechargeable battery system supported by a detachable, wireless inductive charging plate integrated into Bluey's tail.
7. **Microcontroller:** A central microcontroller to handle input/output, manage sensor-actuator communication, and control the flow of operations.

References

- [1] B. Ullmer und H. Ishii, „Emerging frameworks for tangible user interfaces“, *IBM Syst. J.*, Bd. 39, S. 915–931, Feb. 2000, doi: 10.1147/sj.393.0915.
- [2] T. Djajadiningrat, S. Wensveen, J. Frens, und K. Overbeeke, „Tangible products: redressing the balance between appearance and action“, *Pers. Ubiquitous Comput.*, Bd. 8, Nr. 5, S. 294–309, Sep. 2004, doi: 10.1007/s00779-004-0293-8.