A designerly perspective on IoT; a growing systems approach

DCM110

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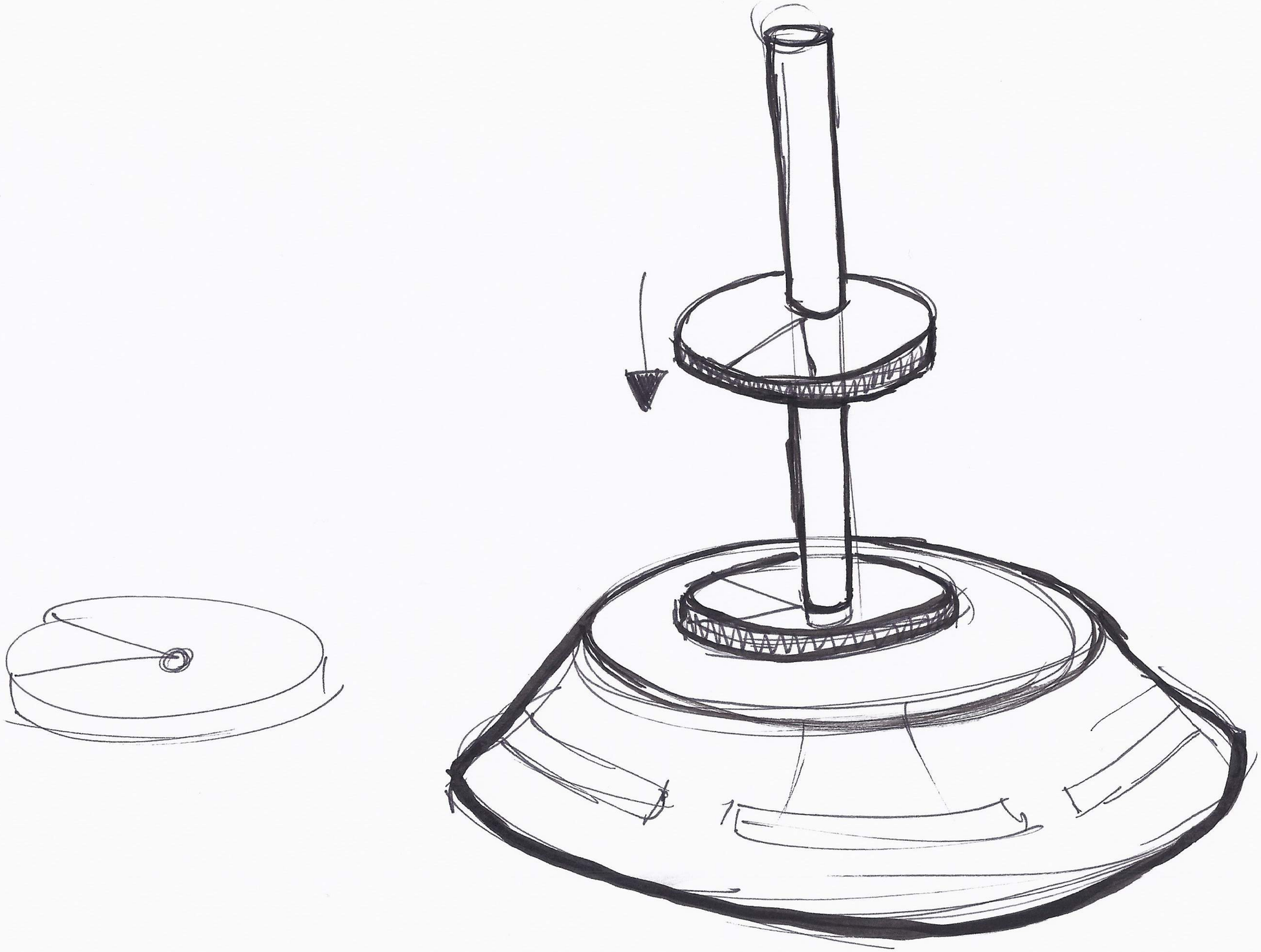

Figure 1. Design sketch made during brainstorm

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Introduction

The world around us is getting more connected everyday. New technologies enable products and services to interact with each other, and with humans. The Internet of Things is an example of this (Vongsingthong & Smanchat, 2014). IoT comprises all Things (objects) that can communicate with each other by making use of the internet, creating a network of devices. The relationships within these networks consists of thing-thing, human-human, and thing-human (Atzori et al., 2010), resulting in a new challenge: how to design for these relationships?

To design for this relationship, the HCI community looks at the interaction we, humans, have with the growing, connected systems. Although it is not fully utilized within the HCI community, researchers found new possibilities to interact with the systems; tangible interaction (Ishii and Ullmer, 1997), embodied interaction (Dourish, 2004) and rich interaction (Frens, 2006). In order to enable the new generation of designers to include these new loci of interaction, Joep Frens lectures a course called: A Designerly Perspective on IoT: a growing systems approach as part of the Master Industrial Design of the University of Technology Eindhoven of which this report is the concluding assignment.

During the second lecture of the course, we chose the topic "Communication / Community" to concretize the challenge we had to face. To define that even further, we decided to focus on the community and communication aspects within student houses. Based on personal observations, we saw that students use digital services (e.g WieBetaaltWat (n.d.)) to keep track of how much money they spend, and especially to fairly divide the costs among the household. We accepted the challenge to redesign this digital service to become embodied and rich, resulting in our concept SPLITTY (fig. 2).

SPLITTY enables students to split the costs they made for the household in a common area in the house. By physically placing your mobile phone in SPLITTY, the receipt of the expense is uploaded in the system. By sliding the know with the mobile phone along the device, students can physically alter the amount of responsibility one has on this particular receipt. In default mode, SPLITTY visualizes the overall balance.

As part of the course, we were invited to design for another topic. "Calendar and Time" was chosen, as we felt it has the most potential in respect to the previous topic and solution. Before students make expenses together, they first have to indicate whether they will take part in the activity that generates the costs. Next to that, we see value in designing for social cohesion among young adults. Especially in these COVID-inflicted times, students are feeling socially isolated, influencing the mental-health of students. Therefore we designed PLANNY (fig. x)

PLANNY enables students to share their daily planning with their housemates. In default mode, students are enabled to see the schedule of their housemates at a glance. When performing a physical interaction, students can see more details of the schedules. Next to the overviews, with PLANNY, students are now enabled to alter their schedule and invite others to dinner enhancing social activities within the household.

Within this report, we attempt to provide a solution for the challenges by exploring an alternative reality in which the interaction with IoT systems are rich and embodied. In addition, within this reality, change and growth is the natural state of the system.
To create a profound understanding of the challenges we face and informed decisions we made, we present our design journey in a chronological manner. Firstly, we start with assignment 2 in which the first iteration of SPLITTY was made. We elaborate on the used theoretical information and how it influenced our design decisions. Secondly, we present PLANNY as a result of assignment 3. Again, we explain which theory we used in the process. Afterwards we proudly present our family of artifacts in which we elaborate on the emergent functionalities we saw, the reason behind the aesthetics and the growing aspects of our concept. Finally, we reflect on the journey we experienced with the help of the courses' learning goals. We close the report by concluding on the journey in respect to the learned lessons and theory of the course: "A Designerly Perspective on IoT''.

Figure 2. First iteration prototype

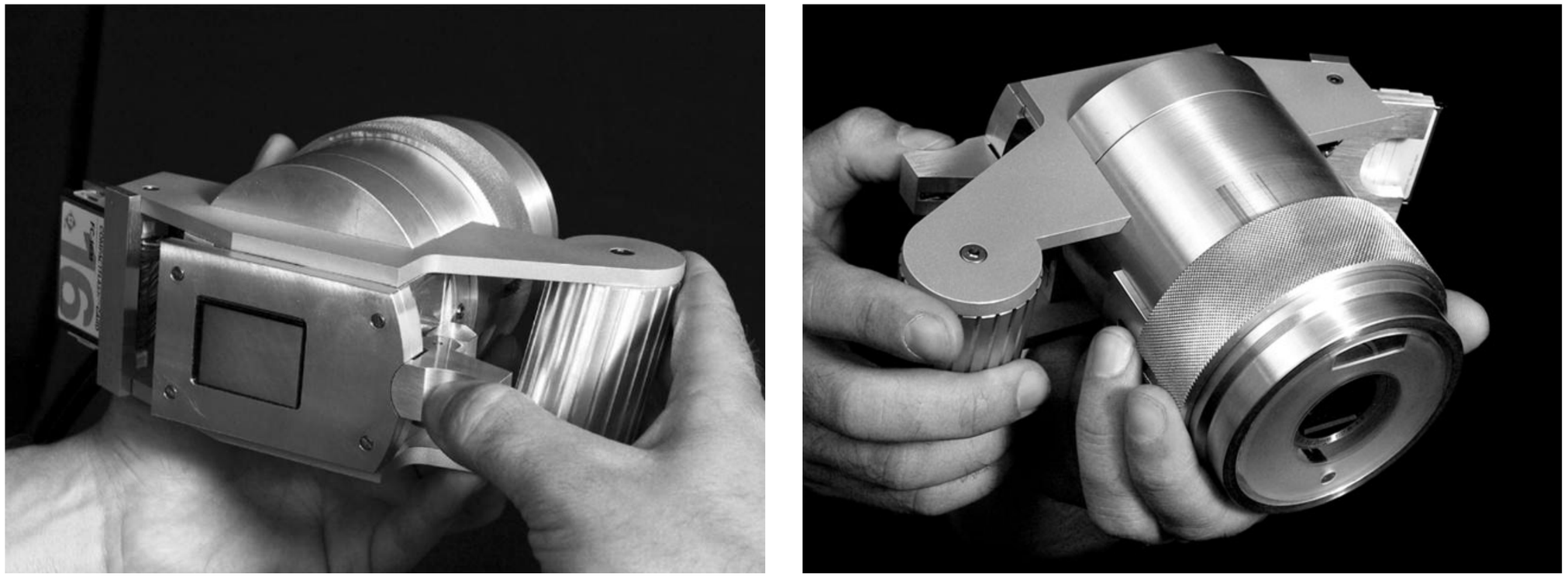


Figure 3. Rich interaction camera (Frens 2006)

Assignment 2

In the Introduction, SPLITTY was introduced as an interactive device that provides an alternative reality for the input and output of the application WieBetaaltWat (WieBetaaltWat, n.d.). This was our group's final answer to the overall course challenge which revolved around exploring rich and physical solutions in the context of Home IoT. In this section, we dive more into detail how SPLITTY was designed before it was actually known as SPLITTY. We will dive into our process and the relationship to the literature and theories on rich, tangible interactions within the context of IoT.

We present our experimental journey in a chronological way. Therefore, this section starts off with our take on the papers provided within the course and other additional related works we found.

Nowadays growing technologies are offering universal and cheap ways to interact with products, mostly resulting in screens with a graphical user interface (GUI). Humans have three types of skills: perceptual-motor, emotional and cognitive skills (Overbeeke et al., 1999). GUIs only use the cognitive skills while the other two are often neglected. Humans learn about the world and its properties by interacting with our environment. They have high spatial and physical skills, thus tangible ways of interacting can significantly increase cognitive skills and can reduce cognitive load while solving problems throughout their life (Serena L., Michail G. 2020).

By combining the realm of tangible interaction with affordances (Gibson, 1986), Frens proposes an additional term "rich interactions'' (Frens 2006). This new interaction paradigm focuses on aesthetic interaction through the combination of form, interaction and function (Frens 2006). While traditional industrial design thinking uses form and function as the main aspects (Heskett, 1980), rich interaction pursues development of form, interaction and function properties simultaneously. By designing for interaction that influences form and function, products with an interesting and elegant user experience can be made. Profound examples of how rich interaction can be incorporated in interactive products are Frens' rich action camera (Figure 3) (Frens 2006) and Lukas van Campenhout's payment terminal (Van Campenhout 2013). The physical design of Frens' camera was shaped based on function and interaction. As a result, a smooth flow of interaction that indicates the action possibilities for the users in a tangible way without any texts, icons or other signifiers was established. For example, when a user pushes the trigger to take a photo, the back panel of the camera is released on the hinge and two action possibilities appear: 1) push the panel to the memory card, thus saving the photo or 2) close the panel to delete it. This creates a physical representation from the digital process of taking pictures, which results in an engaging interaction for the users.

During this project, the goal was to create a device that affords rich interaction and focuses on the perceptual-motor skills. The emphasis on physicality is used to create a simple, easy to use device, in which form would indicate the product's functionality and the way of interacting.

First iteration of SPLITTY

The task at hand was to design for rich interaction by creating an IoT device for WieBetaaltWat (WieBetaaltWat, n.d.) in the context of our chosen topic, Community / Communication. To understand the design journey that we experienced, we feel that a better understanding of the concept behind the first iteration of SPLITTY is necessary. Therefore we present SPLITTY more thoroughly in the next paragraph.

The artifact we created is a tabletop device that allows a student household to split a bill according to all individual shares. In the figures 4.1 until 4.4, the functionalities of the prototype are visualized.

Figure 4.1: putting in the bill

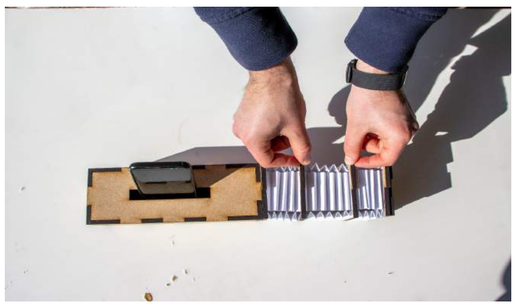


Figure 4.2: dividing the shares

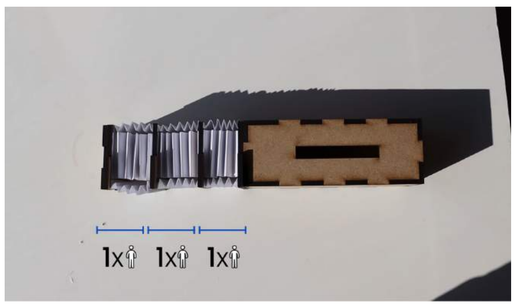


Figure 4.3: representation of equal shares

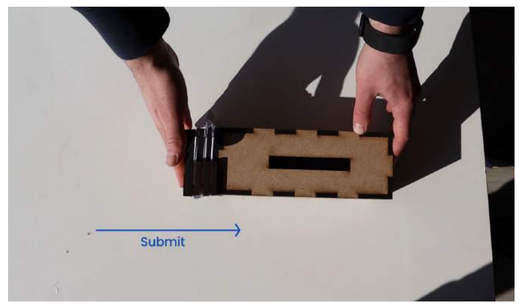


Figure 4.4: submitting the share division

Although the interactions above speak for themselves in this ideal situation, we felt that our concept should be able to help out in more complex situations as well. It happens from time to time that not all house members eat at home or that one member invites one or more persons for dinner. To divide the dinner bill in such situations, a different interaction that enables a differentiation in division is required. This is shown in the visual representation in Figure 5.

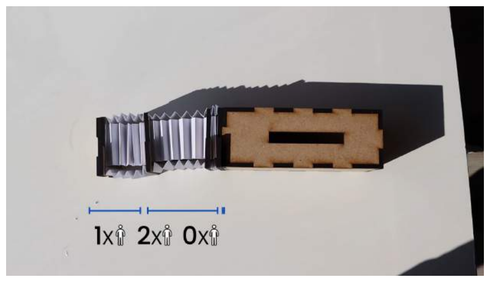


Figure 5: representation of shares when one house member is not home and another member invites someone else

Complexity of sharing costs does not end here. Reflecting on the iteration, we found numerous other situations where our concept might not be an effective device as hoped. To give a scenario: household goods like toilet paper are contained in the dinner bill in the situation of Figure 5. The person that does not join for dinner does need to pay for the goods but not for dinner, while the doubled up person needs to pay two shares of the dinner bill but only one share of the goods. In such situations, separate bills are necessary. To refute this reflective critique, similar complex scenarios currently occur with WieBetaaltWat (WieBetaaltWat, n.d.) too and separate expenses need to be submitted to reach the correct division. We therefore see that the issue merely translated to our first concept. We believe this is not necessarily a problem at this point, as we articulate it as a missed opportunity. The reason why we did not take up this opportunity, is presented in the next subsection about our explorative journey in the world of rich interaction.

Figure 6. Interaction with first iteration of design

The iterative design journey

In the early stages of our design process, the main focus was to come up with ideas that would get us going with designing an interactive device that combines form, interaction and functionality in a logical way, as the theory suggests. Although we implicitly expected that pieces of the puzzle would "fall together" during our ideation phase, designing for rich interactions with IoT devices turned out to be much more difficult.

The overall process that we went through is summarized in the visual below, figure 10. It represents a Tesla valve. Imagine if water is flowing through, then the flow of water is disturbed by itself. This is very presentative of our own design process. In the visual, some turning points are highlighted and are discussed a little more in depth.

WieBetaaltWat (WieBetaaltWat, n.d.) was broken down into input and output actions and functionalities. While sketching and fast prototyping, most of them were translated into physical interactions inspired by existing devices as shown in Figure 7. We also found that the application -WieBetaaltWat- mainly consists of form and function, resulting in a lack of action possibilities (interactions) as shown in Figure 8.

The problem we soon encountered was that seemingly successful combinations of promising interactions were either illogical, inconvenient or just a "Frankenstein"-of-interactions. The reason for this was that these combinations would lack in either of the elements of the rich interaction trinity: a subtle interaction would lose functionality, a pleasing form would reduce interaction possibilities and so on.

We identified this problem and looked for solutions in the literature. We found that we did not focus on the relationships between the three properties of interactive products that were presented in the related work section. At that point, the Six fields of exploration of Frens (Figure 9) (Frens, J. W. 2006) became a guidance in our design process.

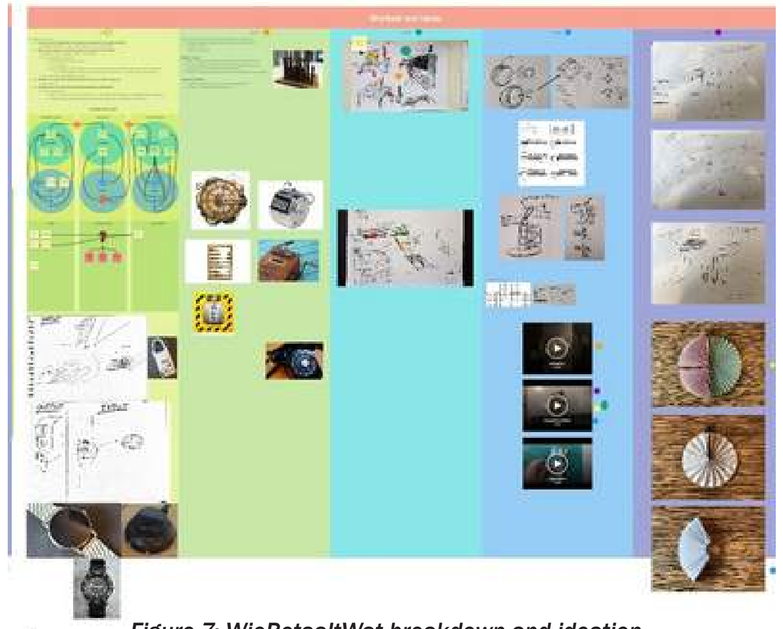


Figure 7: WieBetaaltWat breakdown and ideation

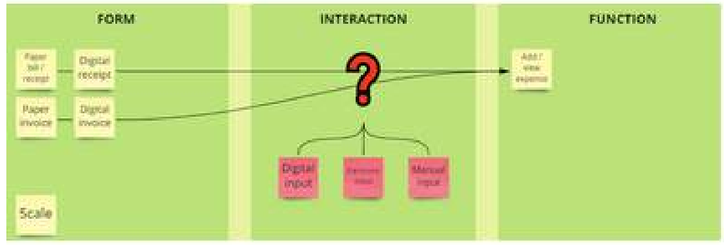


Figure 8: the lack of interaction for WieBetaaltWat

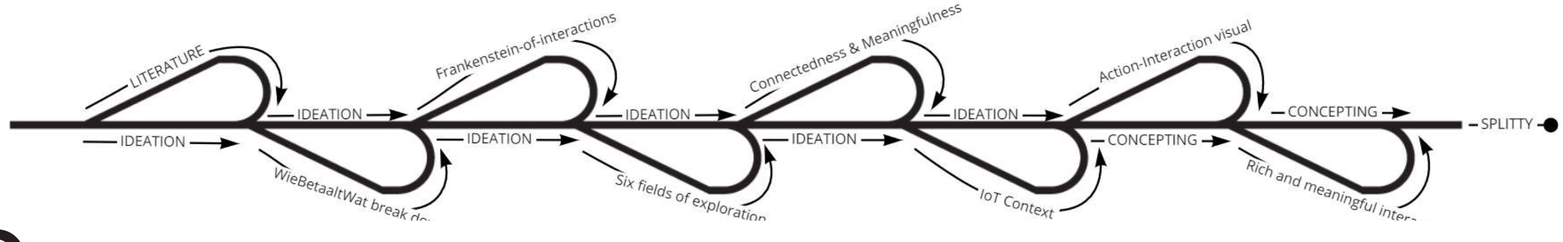


Figure 10: representation of our design journey for SPLITTY

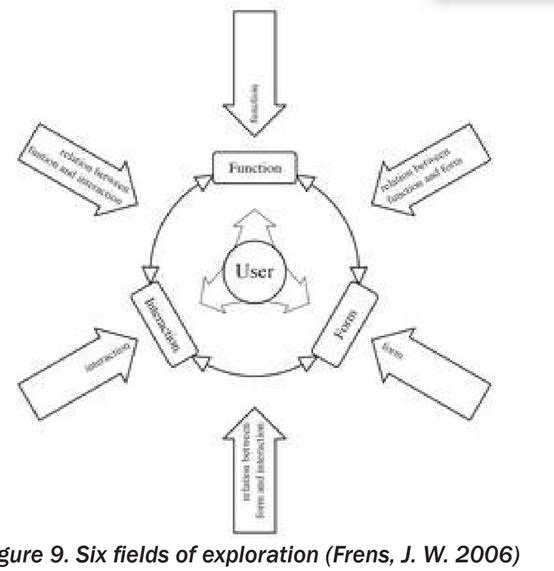


Figure 9. Six fields of exploration (Frens, J. W. 2006)

The iterative design journey

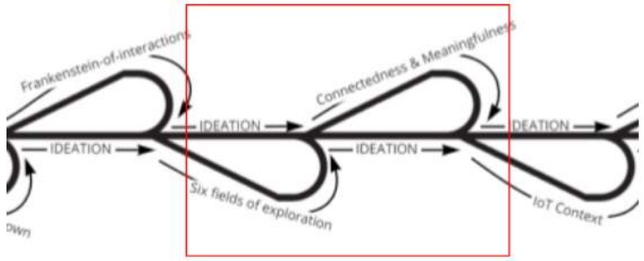


Figure 11: Representation of our vicious cycle

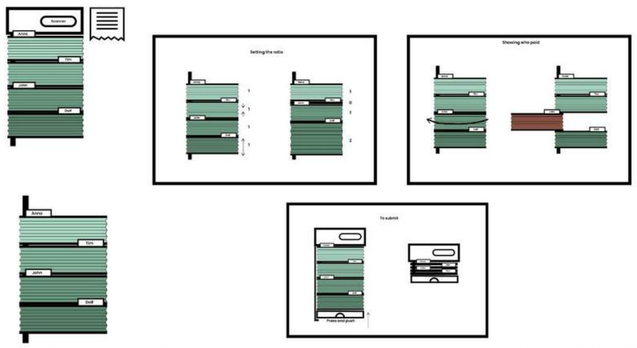


Figure 12: The idea which initiated the concept for SPLITTY

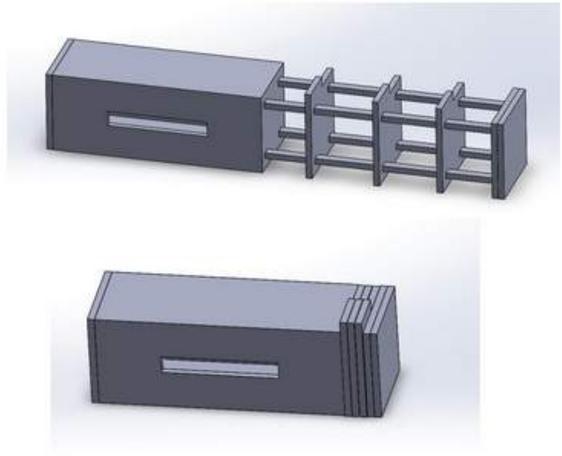


Figure 13: A digital mock-up for SPLITTY inspired by an archive cabinet

We explored these relationships and came up with some profound ideas, but none felt convincing enough. Our group ended up in a vicious cycle of reiterating on our ideas. It was when we received some critical feedback during a design critique session in one of the lectures, that changed our perception on designing for rich interaction. Form, interaction, functionality and their relationships are essential for rich interaction, but it is the connectedness and meaningfulness that makes rich interaction "rich" in the context of IoT. Reflecting on this feedback, we noticed that we unconsciously had started to neglect the IoT-context for which we intended to design for: student households. So we went back to the start, to the problem which we had recognized and formulated a new design task: creating a meaningful design which enables student households to interactively divide costs.

At this point, our new main focus was to combine form, interaction and functionality to establish meaningfulness. We went back to the interaction drawing table and created a visual representation of our perception of WieBetaaltWat (WieBetaaltWat, n.d.) (see Figure 14).

We found different interaction opportunities and ideated on them. We aimed to focus on the artifactual interaction. We chose one of the ideas proposed during a group meeting as shown in figure 12 as a basis to continue on during our journey.

We found the form and interaction very strong in this idea and wanted to improve the functionalities. By sketching a lot, the idea turned into a real concept which we were all enthusiastic about since we believed it was rich and meaningful. The scanner element was turned into a phone slot. This decision was inspired by the Albert Heijn To Go registers and it reflected connectedness nicely. We also decided to make the division tabs horizontally as it reminded us of an old archive cabinet (figure 13).

As we now knew the goal, functionalities and basic aesthetics of our concept, the concept very soon took on shape. We created the prototype for SPLITTY and finalized the assignment. Final shots of the prototype are shown in Figures 2 and 6.

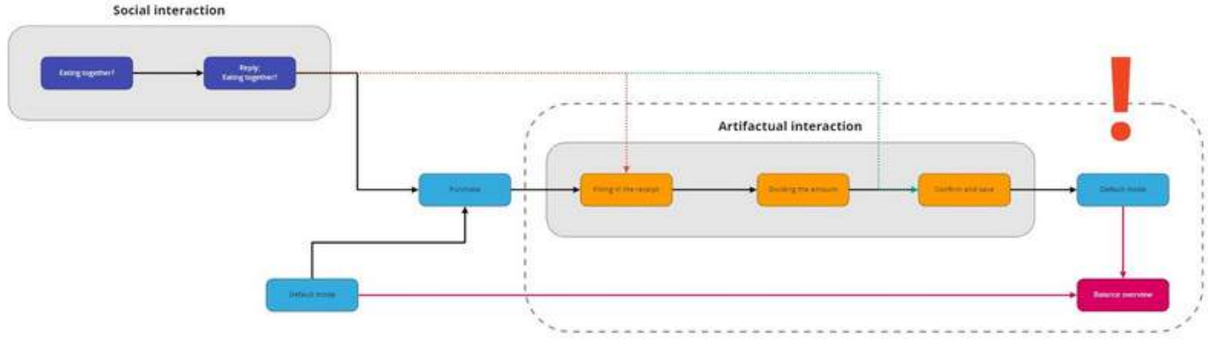


Figure 14: Actions and interactions for WieBetaaltWat visualized in Miro

Assignment 3

For assignment 3, we chose to implement the topic calendar & time. The initial direction we wanted to follow was to create a tangible variant of "Datumprikker" (Datumprikker, n.d.), which is an application that allows a group to select a suitable date to undertake an activity, by all filling in their availability. Our aim was to create a system that would allow student households to set up plans together for dinner, and other activities.

Rich interaction in growing systems

The Internet of Things technology is rapidly coming to our lives. It offers the connectivity between the devices within the same network or outside of it. IoT systems can be open and changing because of their ability to add or remove devices from the system (Frens, 2017). This dynamic system brings the capability for the system to grow which leads to emerging new functionalities when the user adds or combines IoT devices. Emerging functionality can occur when independent devices have separate functionalities that create new functionalities when combined (Steels, 1991). It makes use of the existing devices and offers a better use of resources. Nevertheless, when designing for meaningful interaction, it can bring confusion, as it is hard to predict the combination of devices and the needed interfaces for them (Frens et al., 2009). While it can be simply solved through expandable digital structures, it is thought to be a 'weak generalist' approach (Norman, 1998).

As mentioned in the previous chapter, tangible, embodied interactions bring benefits to the users. Nevertheless, in many fields, for example smart homes, these styles of interaction are not widely implemented by the industry yet. Currently the most popular interfaces for IoT systems are touchscreens and voice control (Frens, 2017). An alternative exploration was done by Frens et al. (2017) where the products for home IoT were made based on a rich interaction framework. The exploration resulted in four approaches to design for this context: hybrid, modular, shape-changing and service approach. In our project we used the hybrid approach when designing for the IoT product. For our design the hybrid growing approach was chosen because of its flexibility and compatibility with our general concept.

Throughout the assignment, we have gone through a multitude of iterations, ultimately dismissing all of them because in our opinion, they did not suit the assignment well enough, or lacked in some other areas. Eventually, we decided to dismiss this idea and focus on the more "average" day calendar, with the main focus on having dinner together.

Figure 15. PLANNY being interacted with

Figure 16. PLANNY in its default state with abstract planning showing

In some student houses, the general area will often feature some sort of calendar, in which students can indicate whether they are home or not. Our concept for the third assignment is based on this phenomenon and is called PLANNY, a wall mounted system that displays the planning of each student of the household for the day, sorted by activities (dinner, university, relaxing e.a.). The system automatically connects to your online calendar and will update accordingly, creating a physical link to a digital system. Our concept consists of two components: a knob, and a rail system with integrated light effects. In default state, the knob is stationed in it's dock, next to the rest of the installation. When placed in the docking station, the user can interact with the knob in different ways. In order to wake up the system, and start displaying information, users need to softly tap the knob. This gesture will turn on a display in the knob, which -by rotating it- shows various icons to indicate which activity is being browsed and, corresponding lights on the rail system will be turned on.. In order to add an activity to your daily schedule, users need to take the knob of the docking station and place it on their personal rail. Once they find a suitable time for the activity, they move the knob -with the correct activity selected- to that time, press it down and move it along the rail to confirm the activity. More rails can be added to the system, making it a dynamic system that allows growth. As stated in the first part of this chapter, with this design, we aimed to create a rich interaction through a hybrid approach, where the screen is implemented in the knob, and the light also functions as information display.

Figure 17: interaction for adding a new activity to your planning

A similar interaction can be executed to extend already existing plans, where the knob can be placed within this activity, pressed and then moved in either direction to extend the length of the activity.

Figure 18: interaction for adding a new activity to your planning

The iterative design journey

Reflecting on ourselves, we believe we started off this assignment on the wrong foot, as we misinterpreted the initial goal. Instead of trying to come up with a new idea, we wanted to find a way to implement the new topic into our already existing device of the previous assignment (Figure 19). We decided to focus on the topic of power and look into the possibility of implementing utility bills into our existing device. After the first week of feedback, when it was pointed out that we were heading in the wrong direction, we scrapped all that we had done and started over. Taking a similar approach as we had done with the first assignment with a new topic time & calendar.

In order to get a profound overview of our possibilities, we had a lot of brainstorm sessions in which we tried to find similarities between our old design, and our new topic as seen in figure 20. With these findings we tried to come up with a setting for our new design. Heading the same direction as in assignment 2, we decided to improve an already existing system, DatumPrikker (Datumprikker, n.d.). We did a similar thing that was done for WieBetaaltWat (WieBetaaltWat, n.d.), and computed all the functionalities of the service, to get a better understanding of the system and its functionalities (figure 21).

The process started to quickly show resemblances to the one we went through during assignment 2, with a lot of vicious cycles, and not being able to agree on certain things. The online nature of the meetings we had, combined with the abstract nature of this course made it really difficult to come to a shared conclusion. We went through many iterations within the process, making very little progress on a week to week basis, since most of the ideas were waved off eventually.

With only one week left in the assignment, and still no concrete finalized design concept, we decided to have a physical meeting at the university. Overall, this was very impactful since it allowed us to ideate in a way that felt way more natural, and worked a lot better for our group. We came up with a concrete idea and direction, where we implement a daily schedule with the main focus of having dinner together, to increase the frequency of the interaction which is what we wanted in the first place. After this meeting, our process accelerated, since everyone faced the direction, and we all completely understood it.

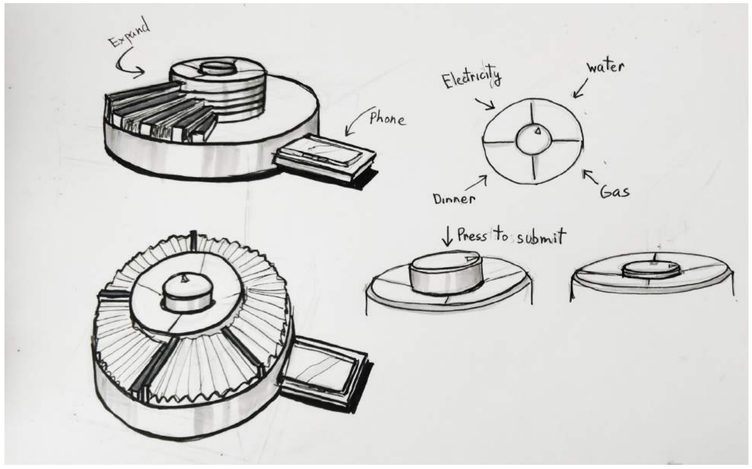


Figure 19.1: Early design sketch of assignment 3

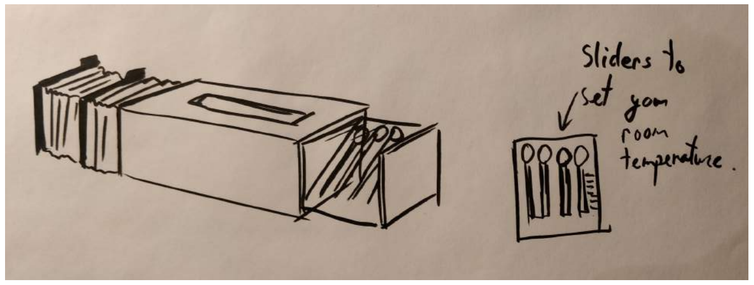


Figure 19.2: Early design sketch of assignment 3

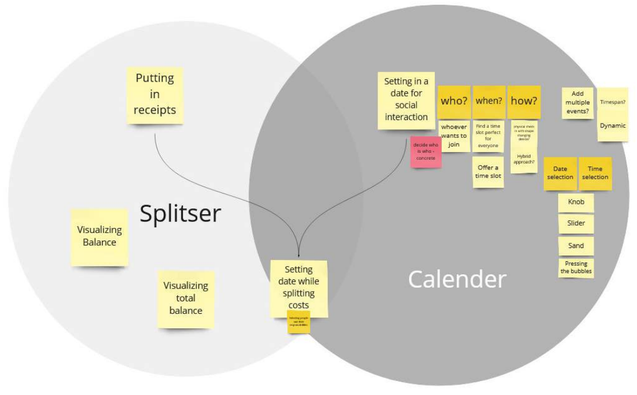


Figure 20: Overlap between the two topics

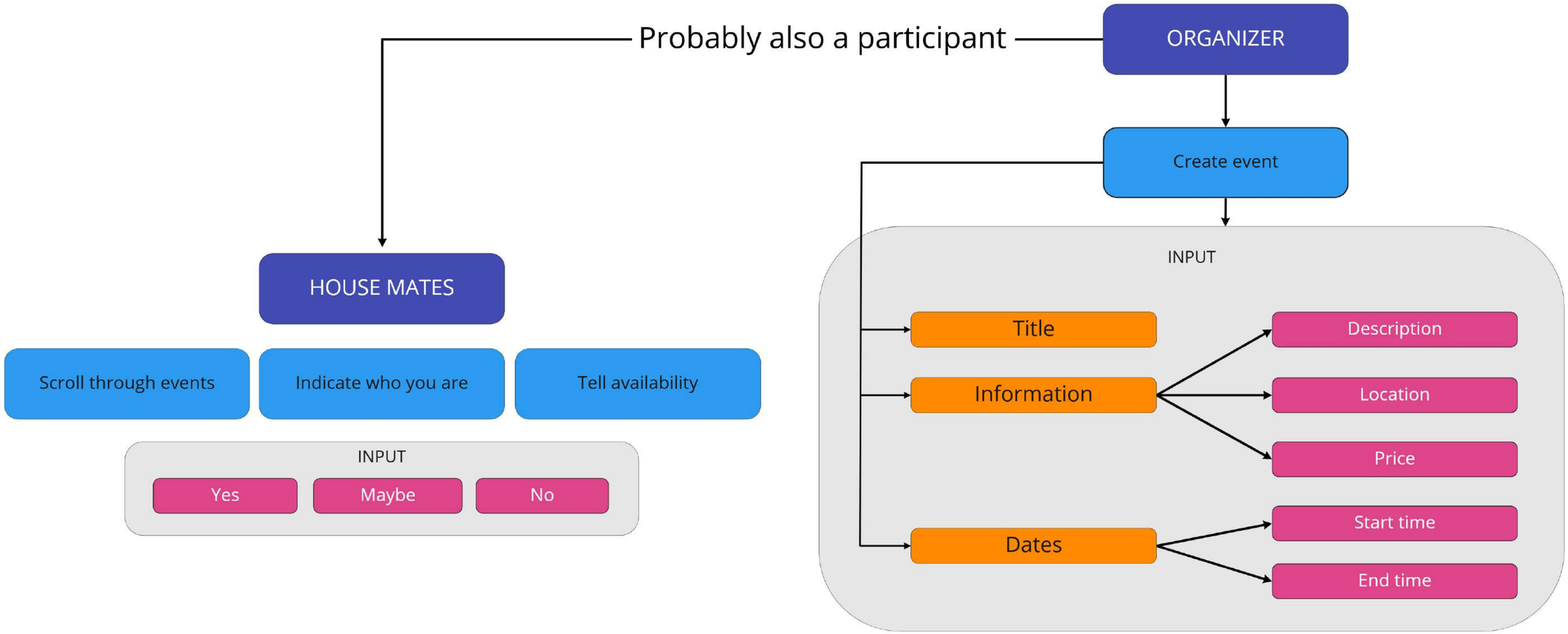


Figure 21: DatumPrikker and its functionalities

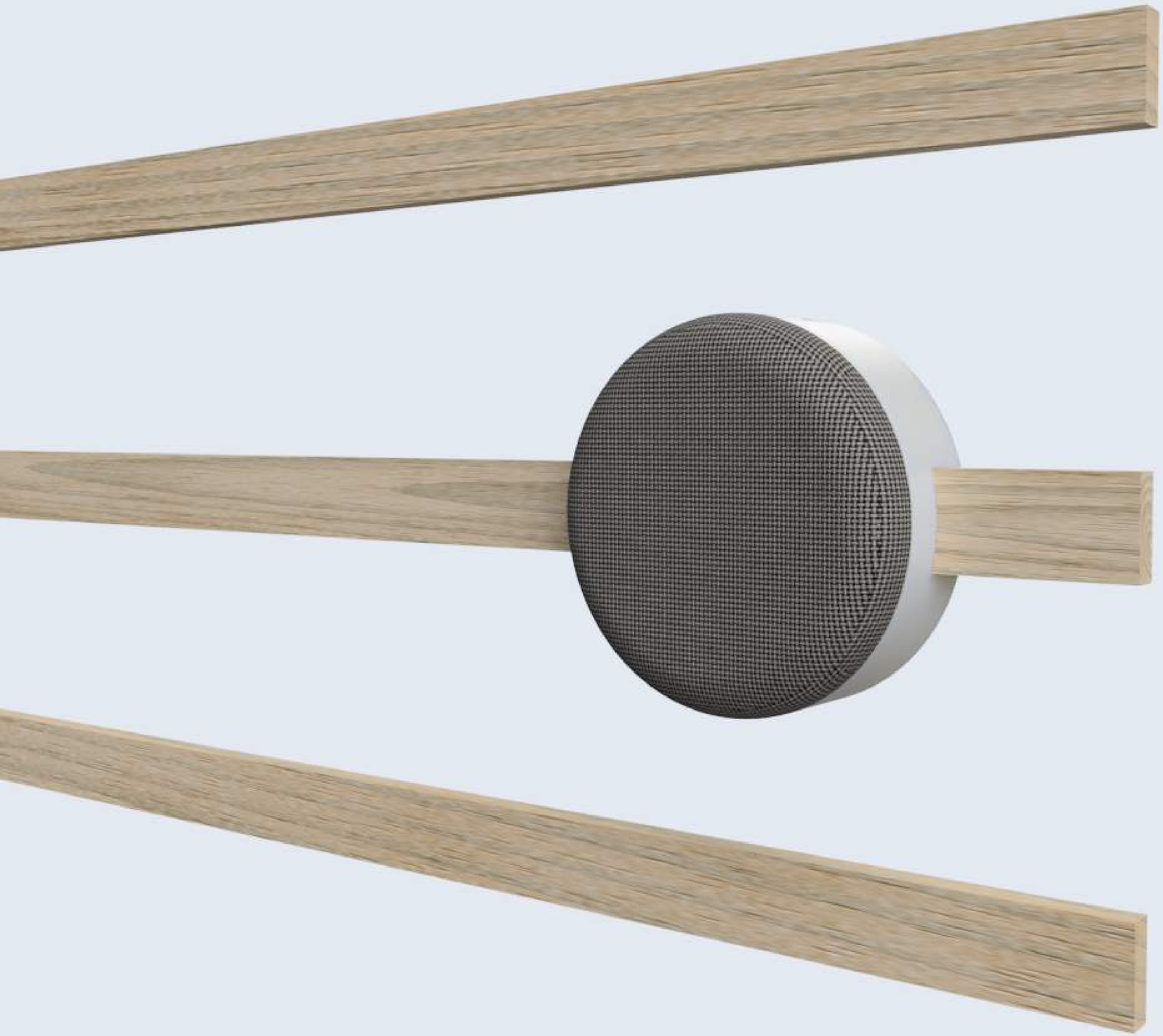


Figure 22.1. Initial Planny renders

Figure 22.2. Initial Planny renders

Family of Artifacts

Once our two separate concepts were formulated, we started imagining how they could coexist in a student home and which new functionalities would emerge. In this chapter we discuss which emergent functionalities we envision for this family of artifacts, how they belong to a form family and how they provide a platform for a growing system.

Emergent Functionalities

Imagine a student house that is planning who will join for dinner tonight. Currently, students in a student house have to transfer information from either oral agreements or chat conversations and a physical bill into the tool that splits the costs over the right people. In the context of a student house, where students eat together frequently with the same people, we believe that the current process is cumbersome. This process should be automated by technology, resulting in a seamless, meaningful relationship between the students and the technology they use on a daily basis.
The connection between a device which aids in planning and shows others what you are doing and another device which can share costs in a student house is made quickly: dinners or other activities can be planned via PLANNY and by sharing the data (such as the bill and participants) through a network, the costs can automatically be divided by SPLITTY. This means no more filling in every bill by hand in WieBetaaltWat (WieBetaaltWat, n.d.) or checking WhatsApp (Whatsapp, n.d.) who joined that dinner you paid a week ago but forgot to put in. This clear relation between the two devices is the basis for our family of artifacts.

When designing for emergent functionalities, we initially felt constrained by the perceived (lack of) action possibilities of our concepts. We also considered that it is possible to combine all the functionalities of our two concepts into one device, but reasoned this would perhaps limit the different types of usages. Through online collaboration it was challenging to view the full scope of opportunities and to think of what changes could be made to allow for more functionalities. After a real life meet up, the physical side of the products was explored more in depth, which resulted in a better understanding of how our intended users would use such products and how they would interact with it. This led to the next step in our design: we decided to keep the two concepts as separate devices.

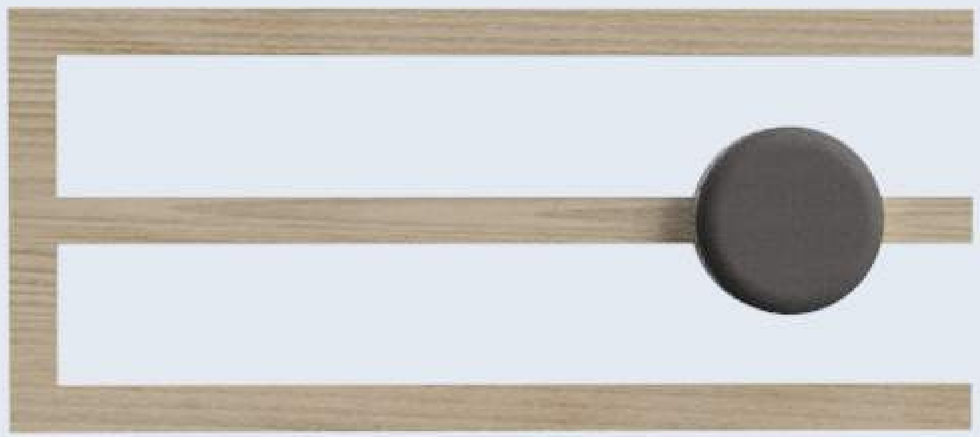
As said, SPLITTY and PLANNY were not merged into one device but instead kept as two separate devices: PLANNY's overview of who is doing what when can be used outside the realm of dividing costs. Housemates could discover they all are going to watch the same soccer game and could watch it together, or find out that everybody is free in the afternoon and they could hang out in the backyard together. This social aspect and opportunities encouraged by this overview are more important and interesting (especially in these COVID-inflicted times), rather than merely dividing costs. On the other hand, SPLITTY's functionalities could also be used for costs that are not dependent on singular planned events, such as spontaneously getting an ice cream. Recurring costs such as the electricity bill or shared Netflix account could also be divided by SPLITTY.

Form Family

Once the minimalistic design of PLANNY was finalized, we were very happy with how intuitive it is and how pleasing it is to the eye. The original bulky and boxy design of SPLITTY did not fit in at all and we wanted to form one coherent group of products with the same design language and identity. Additionally, we found that the axis and rotary knob system was very user friendly and could be used to achieve the functionalities of SPLITTY as well. Therefore, we redesigned SPLITTY to match the look and feel, and operation of PLANNY, which -in our opinion- improves both the aesthetics and the ease of use of our family of artifacts.

Growing system

As different people will have different uses for our systems, it was important to leave emergent functionalities (Frens, 2017) up to the user's needs and desires. The ecosystem in which SPLITTY and PLANNY live, has room for more devices or systems, such as the ones designed by the other groups in this course. This allows for a growing system which fits the (changes in the) user's dynamic lifestyle. For instance, a temperature monitoring device could check PLANNY to know who is home when and adapt the temperature accordingly. If the inhabitants of a student house then have different temperatures in their room, different costs for heating could then be charged via SPLITTY, resulting in a growing connected IoT system. Overall, the design of SPLITTY and PLANNY allows for emergent functionalities and a growing system.



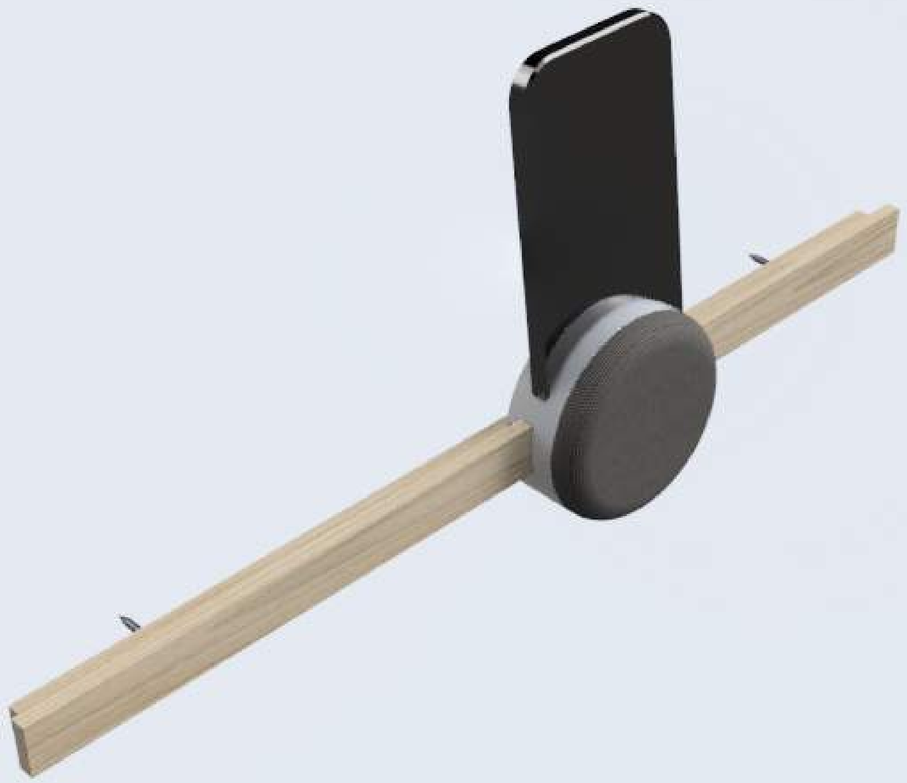


Figure 23. New SPLITTY device

Discussion

Throughout this course we have explored the realm of rich interaction and growing systems and attempted to design an IoT system, which did not come without challenges. In this discussion, we will elaborate on the challenges we faced and what additional work could be done to further improve this project.

Reflecting on our project, we see that the integration of the concepts SPLITTY and PLANNY could be done better. Firstly, we see that there is no uniformal meaning of the horizontal and vertical axis on both devices. While the horizontal axis in SPLITTY means people, on PLANNY people are represented in vertical axis. These different meanings can be confusing for the new users, thus should be solved with redesigning one of the devices. Secondly, although the emerging functionality - the wireless and automatic dinner receipt splitting (SPLITTY) based on the people who were available during the dinner (PLANNY), seems a convenient and efficient solution. Nevertheless we believe that because of the hectic nature of social life, more universal, specific interaction should be created. For example, we could use the rotating knob of PLANNY to select specific activity and then physically transfer the knob to SPLITTY to indicate for what exact event and to whom the bill is needed to be split.
Moreover, we find that there is an opportunity to explore more physicalities to tackle the complexity of the devices. Interaction modalities such as haptics (Hayward, 2004), resistance could be used to indicate specific information. For example, small haptic feedback on SPLITTY could indicate when a specific person's part of the bill is doubled or tripled. For PLANNY, the vibration could hint how many hours the user is sliding through when creating new activities. In addition, for SPLITTY a moving resistance on the slider could be added to relatively express the person's total amount of debt when altering the responsibility of the new added bill. Additional physical modalities could increase the amount of information the system can provide in a tangible way and make the devices more useful, with more engaging interaction.

The focus on physicality within the assignments also led to challenges at times: initially we felt that a lot of problems related to our topics of community and calendar/ time could be solved with just a screen or an app. However, due to the expectations/ constraints of the course, we had to design (what felt like) a less efficient/obvious solution which was more physical. The thought that the problem we found and the solution we created, could also simply have been solved by connecting apps sharing data, still roams in the back of our heads. In a way, the whole physical aspect was just applied as a requirement for the assignments. However, the physical aspects showed their value (in terms of relating a logical interface to the action possibilities) once the prototypes had been made and the design was already finished. Although we see the level of convenience a screen could bring, we value the creation of rich and meaningful interactions with products and services, in line with David Rose (2015).
The late appreciation for the physicality of our work is perhaps caused by the fact that the current pandemic has led to online education and group work. This is an environment which is not very encouraging for physical explorations, which is crucial for this course. The many hours spent online discussing concepts seemed so much less productive and satisfactory than the few moments we spent together and worked offline.

Lastly, the ecosystem proposed in our project could also work outside of the context of a student house. Once students graduate and leave their student houses, they do not necessarily need to get rid of SPLITTY and PLANNY. By having a PLANNY or SPLITTY device in their own homes or office environment, groups of friends or colleagues could see what they are up to and plan events. This could improve the feeling of togetherness, particularly during the current global pandemic. For future work, one topic which we advise exploring is the fact that people only have a limited number of axes at home, and therefore a limited number of plannings they can see. For use in multiple households, a solution to this issue would be required. Another interesting topic would be to explore how other functionalities could be added to the current artifacts, in order to account for the growing system.

Conclusion

The course A Designerly Perspective on IoT: a growing systems approach challenged us to explore the theories of rich and tangible interactions and the growing systems approach and seek action possibilities to apply them together in the world of IoT. We designed a family of artifacts consisting of the devices PLANNY and SPLITTY, as an answer to this challenge. We have positioned ourselves within this context by creating meaningful designs that allow for further growth. We were challenged by the online nature of this course while we learned a great deal about the theories and how they can be interpreted in numerous ways. This required us to convince one another or oneself to find some consensus. But in the end, we were able to overcome this and we are satisfied with the end results. As written in the course description "It seems that many of the lessons that were learned from research areas ... are not landing in IoT" (Frens, 2021). With the help of this course, we can conclude that there are now five future designers that are motivated to create change and redesign the relation humans have with connected products and services.

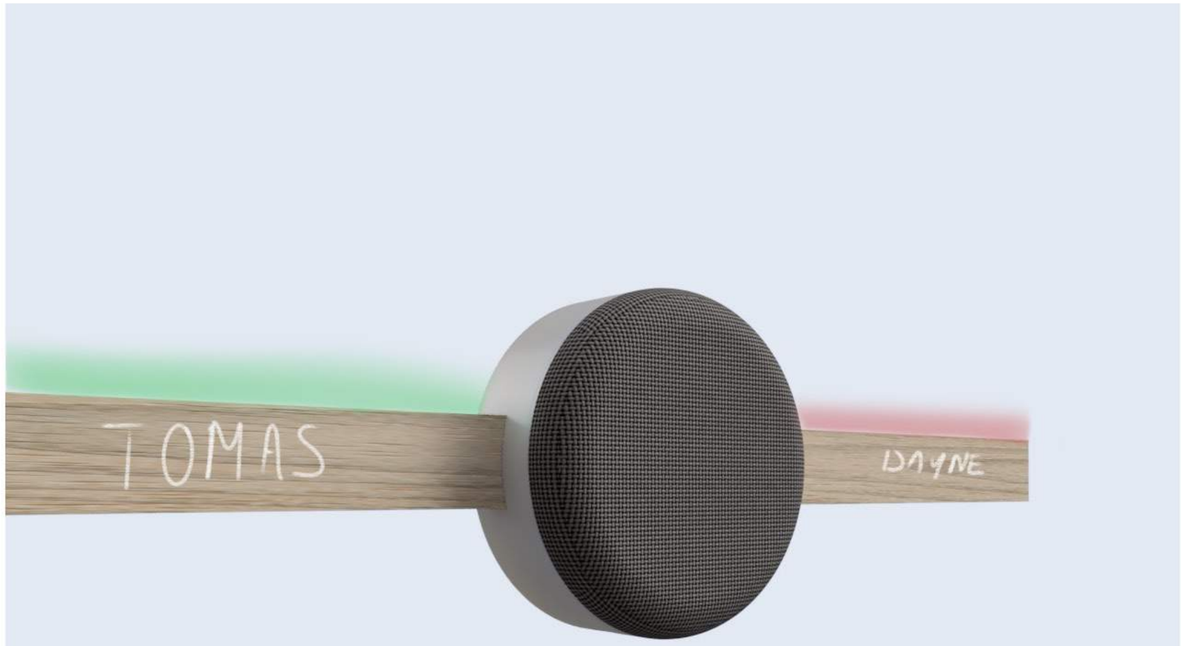


Figure 24. Render of new SPLITTY device

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Personal reflection Dayne Oomes

I chose this course to guide me towards the RDD track while I personally also wanted to learn more about the world of IoT and growing systems. It also allowed me to challenge myself within the expertise area of Creativity and Aesthetics. I have focused myself on combining materials science and design. For this course, I was very much interested how form and functionality relate and how this can be experienced.

During the elective, I met the theories and creative process regarding rich, embodied interaction and the growing systems approach. At first, I was intrigued by the theory because it was a new perspective on the digital world around us. I was familiar with some of the theories presented like the one on affordances and the frogger framework, but the growing systems approach was a new light to me.

Throughout the course, I explored this world of rich, embodied interaction and emergent functionalities. But I am still not fully convinced by this theorem. I understand the principles of the theories that the papers present and find their reasonings very legitimate. But when applying the theories, I have been feeling that the overall take of a growing systems approach was more so a perspective than an actual design framework or technique. I find the papers fairly substantiated, but during applicationI felt that the freedom of interpretation was very much the guiding line rather than the theory itself. I have been battling with the interpretation ever since the course started. This is exciting in one way because it creates new insights, but on the other hand it was very challenging to deal with these sudden informalities. I often debated with myself during the ideation and exploration phases of our group project and I took these issues with me to discuss in the group meetings. I started to notice that other group members had similar issues which caused some of our meetings to be extensive, exhausting and inefficient because of the endless debates on our personal interpretation with the theorem which regularly differed.

Looking back, I see the online nature of education as the cause for these inefficiencies. First of all, I personally have experienced some mental setbacks due to the situation which influenced my energy and concentration levels greatly. I have been dealing with this and things are improving. Next to that, our group had one actual physical meeting on campus and the majority of our group issues were resolved within barely two hours. The ability to discuss and explain the theorem in person was vital for our process.

All in all, this course very much challenged me. It was both a personal and educational learning experience. I was able to explore opportunities to combine form, functionality and also interaction. I will take this with me by updating my current personal development.

Personal reflection Tomas Gecevičius

After "A designerly perspective on IoT'' course I drastically improved my understanding of the embodied, rich interaction. This course introduced me really well to the concept of affordances, taught me the rich interaction framework, about the IoT systems growth, and how physical rich interaction devices could be integrated into them.

During this course, I studied the notion of affordances (natural and artificial) and learned that different researchers (Gibson and Norman) can see the same term in a different way. In addition, the course introduced me to an alternative way of designing physical products in which together with functionality and form, interaction is also simultaneously designed. While creating a meaningful union of all three aspects, physical devices with rich interactions can be developed that could have physically interesting experiences. While I am passionate about digital interactions and experiences, now I really believe that for physical appliances we use unnecessarily a lot of screens and miss an opportunity to create pleasant tangible solutions.

In addition, I am fond of IoT products and interested in smart home systems, but I never thought that it is possible to have meaningful IoT devices with tangible interfaces when the majority of them are controlled by mobile applications, screens, and voice. Moreover, after reading the research papers it was complicated to understand the emerging functionalities part and how to make it meaningful, nevertheless after struggling with it, the Q&A session brought me to the right track. While now I understand that as a designer it is not possible to think up all the feasible ways how the developed product could create additional functionalities when combined with other IoT devices, I am definitely going to explore it more in future projects or at least think up ways how to make it easier for the users to create their own emerging functions.

One of the biggest obstacles during this course was remote learning and group work. I found it complicated to brainstorm and discuss with the team physical devices which have a focus on tangible interactions while showing only digital sketches or small videos. Working only online, removed the possibility to demonstrate ideas with body movements, gestures, by using some kind of materials or by just simply sketching on top of each other's drawings.
Overall, I really enjoyed this course and lectures. The sketches during the Q&A sessions were really helpful and the literature list expanded my mindset on the IoT systems. I wish that I had this course at the beginning of my master's studies, as it would have helped me during my other projects.

Personal reflection Thomas Marinissen

I chose this course for a few reasons. Firstly, because it fits in my RDD track. Secondly, because I had a positive experience regarding the lecturer's approach to designing IoT and growing systems in my M1.1 project. Lastly, because I was interested in a course related to the expertise area of aesthetics & creativity, something which is trained through the explorations of rich interaction.

Some aspects of the theoretical background regarding rich interaction and growing systems was already clear to me as my M1.1 project was in the DIGSIM squad. This probably helped me to contribute to the group work, although we struggled a lot. The thing I most struggled with was the fact that it felt as if the rich interaction and physicality demanded by the assignments was more a constraint than an actual design approach. Maybe I think too much about how realistic or cost-effective a design is, but I can't shake the idea that, even though our concepts are nice and functional, students would rather have app integration to fulfill the same functionalities. Particularly because that would be free and would not require more devices. Only once our design was finished, I saw the possible benefits of the physicality. It would have been nice if this realization would have come earlier.

This relates to another thing I struggled with: it is very hard to design for physicality without physical meetings. I think our group got demotivated at times due to endless discussions in Teams that seemingly led nowhere. Only seeing your group mates behind a screen and only presenting ideas on Miro or in a call does not allow for ideas to spark or sink in as much as real life meetings. Obviously, this is not the fault of the course, but a consequence of the current pandemic. That being said, I do believe that we would have enjoyed the project more and come with more meaningful physicality if we would have had the opportunity to sit together more often.

Now that the course has ended, I can reflect on what I learned and what I will use in my future (as a designer. I think this course asked me to design according to the constraints of physical interaction which forced me to come with solutions I would otherwise not have come to. I think in any design case, you are constrained and must find creative solutions. The more I do this, the more comfortable I get with it and the better my solutions will get. Seeing the physical interaction in the end also made me appreciate its aesthetic value and opportunity for intuitive operation. This gives me hope that our future does not only consist of screens, although I am unsure how this would be combined with companies' desire for cost cutting. I am also unsure about my interest in IoT: I see and understand the benefits of connected devices, but do not feel the urge or necessity to have them in my own life.

Personal reflection Wiebe Audenaerd

If everything goes as planned, this is the last course I had as part of my Masters. That is why I thought carefully about which course I should choose to develop myself the way I wanted. Reflecting on the designer I want to become, I noticed that my education missed 'building academic arguments to support my physical design decisions'. Next to that, I searched for a course in which I could "design with my hands". After having mail contact with Frens in which the learning goals and structure of the course became clear, I decided to enroll myself for this course.

Throughout the course, I was introduced to new perspectives on how to design for the relationship between humans and their connected "things". As we see the world around us getting more connected, gaining an understanding of this relationship is valuable for the designer I want to become. The course started quite relaxed, as I already had knowledge about the theory of affordances. With the help of the literature and the assignment in which we were challenged to first-hand explore the realm of affordances, I refreshed my memory. During the subsequent assignment, I was introduced to tangible, rich and embodied interaction which educated me to understand the link between affordances and designing for meaningful interaction within IoT networks. I learned several methods and frameworks to design for rich interactions which we could apply within the second assignment. As the course went on, I learned about using a hybrid, service, modular and shape-changing approach. Finally, I learned how to position myself, and my work towards the growing aspect of interactive devices within IoT systems and networks.

Reflecting on the process I experienced, I must highlight the difficulties I encountered due to the online structure of the course. I struggle a lot with elaborating my ideas in online meetings and I found it hard to understand the ideas of others, resulting in inefficient discussions. As learned, I realized that creating physical prototypes to interact with, helped our group to move on. A striking insight that this course gave me, came during the one physical meeting we had. It felt way more natural to look people in the eye, when designing together for physical interactions. As I wanted to "design with my hands", I took the responsibility of the physicality of our concept. I learned that I get energy out of this process and I like to believe that this is one of my strengths. I noticed that it also boosts my inspiration for my Final Master Project. As it focuses on 'tangible interactions with mobility services', I immediately saw how I could use the learned methods and theory to improve the quality of my project.

Looking back, I am enthusiastic to implement the learned lessons in my future career, and challenge the decision makers to look beyond the glass slab industry (Rose, 2015) and rethink the relation humans should have with the physical and digital artifacts in our future connected world.

Personal reflection Milan de Meij

I decided to select this elective as my track course for my RDD track. This is a direction within design that I have taken a great interest in over the last two years of my study. I did not really know what to expect from this lecture, apart from the fact that I was expecting it to really focus on interaction design, which is a subject that I haven't been able to focus on as much as I would like, I think interaction is extremely important within design, it allows users to go through a journey with your device in many different ways, based on how you want them to go.

My background in creativity and realization is alright I would say, I tend to take a very abstract approach from time to time, I was hoping this course would allow me to take a more artistic approach to design as well, this didn't really turn out to be true, which is fine. I still learned a lot, even though it was in a different way than I anticipated beforehand. I was already a bit familiar with the concept of rich interaction from previous courses, but never really focused on it in the way that we did during this course, that was a big learning experience for me. There's a lot that needs to be taken into account when you are designing for the interaction specifically. IoT is a subject I haven't really been working on, technology is very important for me, and connectivity is a big part of that currently, but it simply doesn't interest me as much as the other parts of this course.

It feels a little bit repetitive to bring this up again, but COVID-19 is still influencing the way we interact within groups as well. Even though we have great tools, such as miro and teams, there's nothing that can really provide the same effect as physical meetings, we really struggled a lot during our online meetings because it was hard to all face the right directions when you're talking about interactions, because you all have different opinions on what matters. The physical meeting we had at the TU/e was definitely a turning stone for me, I plan on doing those more often (when it's safe enough obviously).