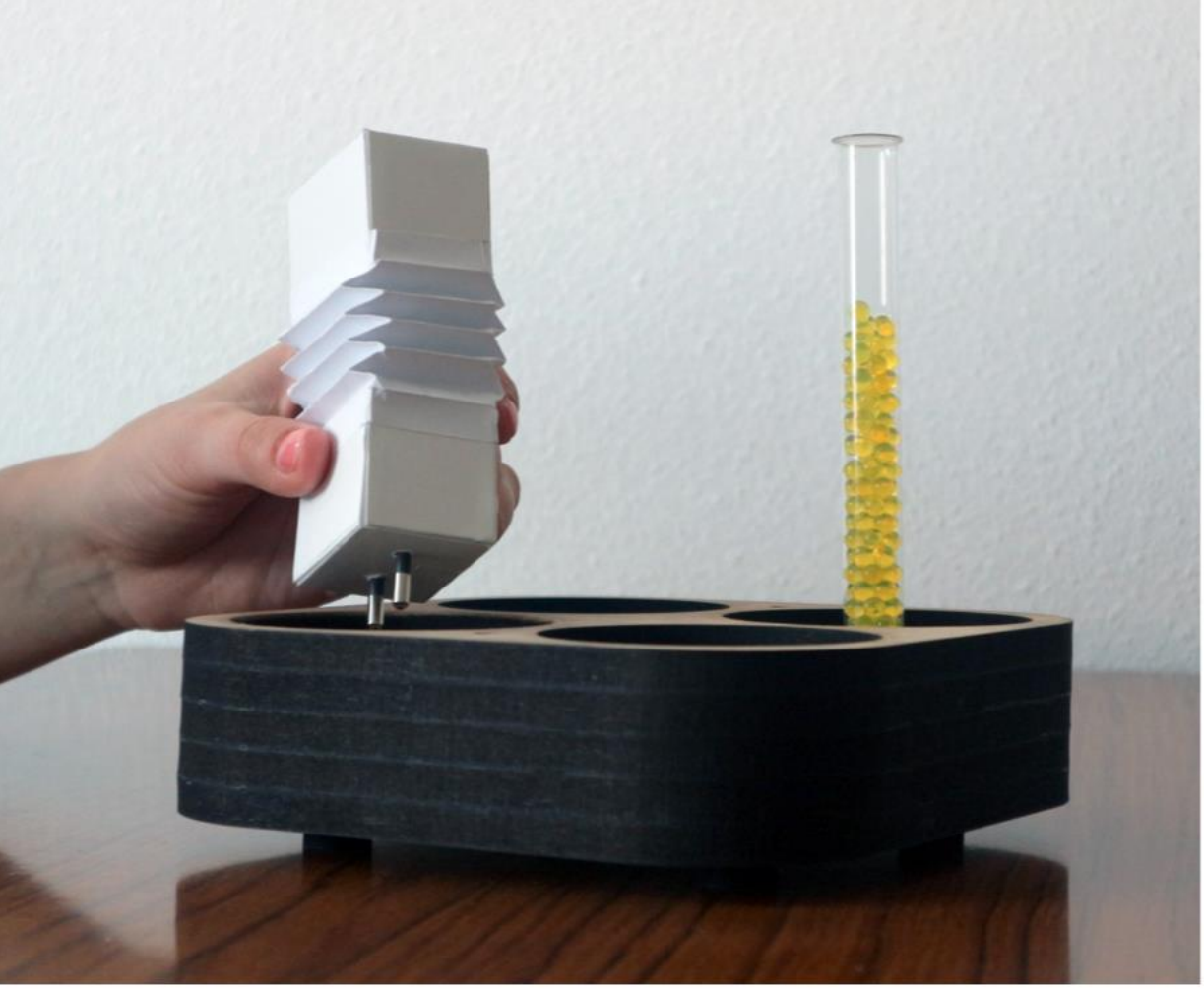

Yes, but... It depends

A design exploration of rich interaction
in the context of growing systems

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Abstract

This report covers the exploration of designing rich growing systems within the smart home context. Three design explorations were performed: a system of localized, tangible adapters which was designed to create awareness of power usage; a central tangible interface that aims to facilitate discussion and community goal setting around water usage; and lastly, a collaboration of these two devices to generate awareness and facilitate discussion around power usage. Through the design cases, concrete possibilities for rich and embodied interactive systems within the smart home were explored. Next to that, emergent functionalities that came from the core functionalities of our first two designs were created. By reflecting on the design process, possibilities and constraints for designing in the field of rich and embodied growing systems in home IoT were formulated.

Introduction

Smart home products are becoming increasingly popular due to their promises regarding time-saving, efficiency and energy consumption. Although smart home products are marketed to lower energy consumption, this is often not the case in reality. One of the reasons for this is the complexity of the system that is being created by introducing more and more products into the home (Strengers & Nicholls, 2017). In this study, it has been explored whether designs utilizing rich interaction can help to decrease this complexity, and instead help users gain awareness and insight. First, the design case of creating awareness of individual power usage was used to design Watts Down, an adapter that goes in between power outlets and plugs. After that, Flow was designed as a means to create communal awareness of water usage. Lastly, the emergent functionality between the designs was developed. The result of this exploratory process is a set of two designs with multiple functionalities created to help homeowners that want to be more sustainable. They provide users with more insight in the usage of power and water (and potentially other home related streams and sources) through rich embodied interfaces.

In this report, the background of rich and multi-user interaction in home IoT is explained first. After that, our work is benchmarked in the field of designing for power consumption awareness and designing for community. This is followed by the explanation of the three design exploration phases and the designs that resulted from these phases. Lastly, we reflect on our design process and, more general, on the role of rich and embodied interaction in the smart home context.

Background

Rich and multi-user interaction

In design, a lot of types of interaction are defined. Examples are reality-based interaction, tangible interaction, embodied interaction, natural interaction and rich interaction (Djajadiningrat et al., 2004; Dourish, 2001; Frens, 2006; Jacob et al., 2007; Valli, 2008). This project specifically evolves around implementing rich interaction in IoT. Rich interaction can be defined as: *"a new approach to interaction research with the goal of designing systems that would more fully engage people's bodies to richly express themselves and people's full range of senses as channels for input and feedback from interactive systems"* (Frens, 2006). Rich interaction intends to utilize all three types of skills as defined by Overbeeke et al. (1999): perceptual-motor, emotional, and cognitive skills. This means that information-for-use involves all human skills instead of using only cognitive skills, as Frens argues is the standard in modern day design. In the design cases as presented in this paper, "form" and "expression" were explored as the main factors to make information-for-use more transparent and apparent (Hallnäs, 2011).

Besides rich interaction, multi-user interaction played an important part in the design explorations as will be presented. To consciously design for multi-user interaction is crucial to maintain system accessibility, since often not every member of the household is equally connected or involved in the interaction. Apart from problems in system accessibility, conflicts might arise because of the flexibility in use and preferences, which get more complex and distinct when the system has multiple users (Niemantsverdriet et al., 2016). To address these problems, three mechanisms were defined by Yuill and Rogers (2012). They argue the success of multi-user interfaces being dependent on: the level of awareness of others' actions and intentions, the level of control over the interface, and the availability of background information.

Power consumption

From a societal perspective, there are two major benefits that stem from limiting domestic utility (water, gas, electricity) 'waste' for the average individual consumer; ecological and financial. Through a process of giving feedback on energy consumption, consumers can be motivated to save energy through reducing waste (Gustafsson et al., 2005). In a study by Xiangyu et al. (2020), the role of awareness is declared to be an important factor when it comes to household energy consumption and making pro-environmental choices. Awareness alone however does not necessarily reduce energy consumption, but rather the subjective factors stemming from awareness play important roles (Xiangyu et al., 2020).

In order for consumers to improve the energy-saving performance of their household, the application of information technology can provide a framework for real-time monitoring and analysis (Wei et al., 2011). By using a connected monitoring system connected through IoT, household energy consumption can be monitored more accurately in order to provide the consumer with more clarity on their energy usage. This approach of increased awareness creates an environment in which the consumer is able to make conscious considerations and decisions related to energy consumption, rather than unconscious or habitual ones, when it comes to everyday interactions with technology (Pierce et al., 2010).

Community design

Domestic utility consumption as described above is not limited to the individual consumer. Rather, the entire household shares responsibility for the collective utility expenditure. In line with shared responsibility and inherent motivation to reduce waste, it is of importance for individuals in a household to share a similar goal. In order to do so, individual consumers are required to discuss with each other both initially and over time in order to set a collaborative goal (Locke, Latham, 1991). Through provision of (IoT based) information in a design artefact, households are given the opportunity and stimulance to internally debate about said information based on factual and informative data (O'Reilly, 1982). Alternatively, non-conventional design approaches based on the aforementioned rich interaction methods are likely to encourage household discussion on the presented information within the design artefact (Franklin et al., 2003).

Design

To explore the design space of rich interaction, two individual concepts have been created. While both function independently, they can be used collaboratively to unlock emergent functionality. During the design process, several activities occurred in parallel: the main design process, which was a team-driven effort; individual exploration; and researching of literature specified by this course and other relevant work for inspiration. All three design explorations will briefly be discussed and reflected upon here. Each chapter starts with an explanation of the final design, followed by a reflective description of the design process including important decisions that were made to get to this final design.

Design exploration 1 - Watts down

Goal: create awareness regarding power consumption.
By means of: friction, but no restriction.
Interaction: insert plug into the adapter and insert adapter into the power socket.
Feedback while interacting: haptic feedback to indicate time or battery percentages.
Feedback after interacting: Once the 'timer' runs out, the plug is disconnected.
Constant feedback: breathing motion to indicate power usage at that particular time.

Fig. 1: prototype of the first concept Watts down

Design process and decisions

For the first design exploration, the theme *power* within the smart home was chosen as the starting point. The assignment specified that our design should be "a Rich Interactive 'Locus of Interaction' for a living room IoT device" (Frens, 2021). The scope was defined further through brainstorming on several aspects of the design challenge, such as target groups, contexts, and objectives. It was decided to go into the direction of designing for awareness of, and taking action on power usage in the home. This was inspired by the notion that our behaviour around electricity is not as efficient and environmentally-friendly as it could be and that connected devices could pose as a solution to this. For instance, many devices use power even when they are not performing their primary function and are switched 'off', a phenomenon known as phantom or standby power (Bertoldi et al., 2009). Starting from these thoughts, we investigated a localized interface that would connect to power-using devices, communicate power usage to its users, and give some control over how much power is used.

Fig. 2: another prototype of the first concept, Watts down, in use

After ideating and developing a variety of ideas, the final concept, an adapter that physically connects to power-using devices and power outlets, was designed (see Fig. 2). Considering the aim to create awareness, it was decided to design a decentralized system in which input and output are unified in one location of interaction (Djajadiningrat et al., 2004). Through using the device, users are made aware of the fact that they are (1) using electricity and that (2) this is not an unlimited resource. Plugging in devices and using power have almost become a subconscious action for many people, leaving many people clueless of how much energy they are (un)intentionally using. By introducing friction when pushing in the adapter, as inspired by the concept of pleasurable troublemakers (Hassenzahl & Laschke, 2014), the consumption of power is highlighted. Next to that, awareness is created through vibrations at certain 'levels' to give an indication of how long power is let through (see Fig. 3).

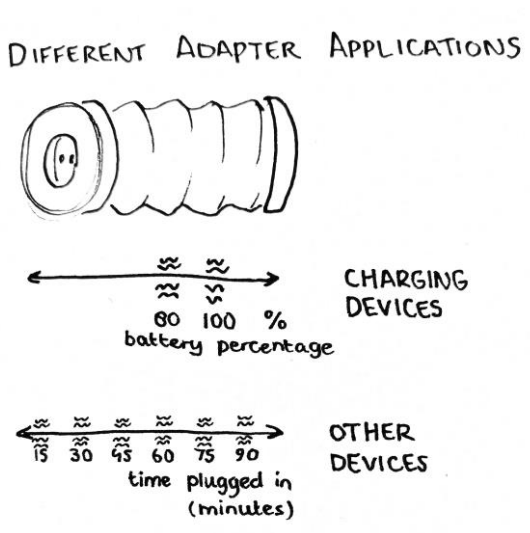

Fig. 3: levels at which vibration happens in Watts down

After designing the adapters, we explored possibilities for extra functionalities by making use of multiple adapters within the same home. To add to the previously mentioned elements of friction, a visualization of the current total power usage was implemented in Watts down, communicating about the collective power usage of all adapters in use. This information-for-use is communicated through a breathing motion that happens within the accordion structure (see Fig. 4; Frens, 2006). When there are many devices connected to adapters using electricity, all adapters reflect this by breathing rapidly. This interaction element is meant to trigger the user into taking action on this peak in power usage, but can still be ignored if this action is undesirable. If the user decides to take action, it can metaphorically 'calm' the system of Watts down adapters by putting their hands around one of the adapters. This results in the device that has been plugged in for the longest amount of time being disconnected, in turn reflected by less total power consumption and thus a slower breathing motion. By creating these extra functionalities, new discussions were held about the data that could be shared between the adapters and the implementation of this data in a meaningful way.

Fig. 4: breathing motion of Watts down

The strength of the Watts down concept lies in that it is actively introducing more physical effort into an existing routine, creating moments of reflection and choice for users at the point of action. Users still retain full agency over their electricity consumption and are individually and locally addressed by this concept. However, the physicality of the adapters simultaneously introduces weaknesses. We found the pushing interaction necessary to set the timer ambiguous, as a user could think that the size of the accordion-structure is the metaphorical 'capacity' of the adapter, thus indicating a different relation between power throughput and size. Additionally, the physical size of the adapters highly affects the amount of discrete vibration points that can be specified, as many vibration points in a small compression distance will possibly be unclear. Yet, this depends on the technical implementation, which has not been explored sufficiently to conclude that this is a flaw. Lastly, we struggled with the impact our design would have on household power consumption, which was secondary to creating awareness but nonetheless important. By later on adding support for non-chargeable (e.g. water cooker, stationary radio), we attempted to address this; however, we realized that Watts down is not as suitable for devices that remain stationary and plugged in all the time.

Design exploration 2 - Flow

Goal: create awareness regarding water consumption.
By means of: insight and goal setting.
Interaction: set goals by choosing a tube and placing this tube and a phycon in the table piece.
Constant feedback: the tubes will represent water usage by filling up with water beads, spilling over when more water than the goal is used.

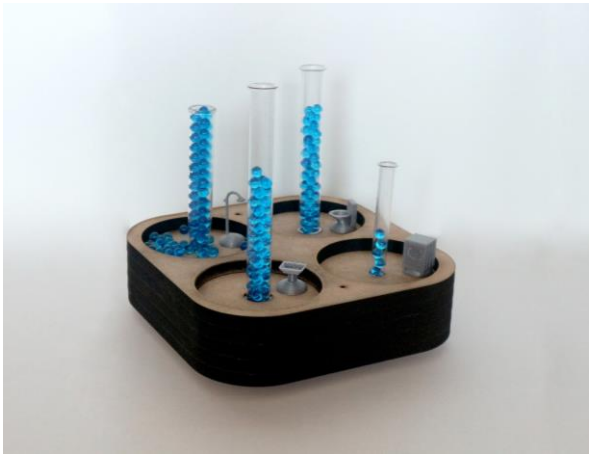

Fig. 5: prototype of the second concept Flow

Design process and decisions

For the second concept, the main topic *communication/community* was chosen, as it promised to be an intriguing combination with power. In line with the previous concept, increasing awareness was the main goal we aimed to further increase the awareness of the users in this design. More specifically put, the formulated goal was to create more awareness of the power usage as a collective, as proven important (Locke, Latham, 1991) and effective (O'Reilly, 1982 , Franklin et al., 2003).

When reflecting on our process, we designed an emerging technology without creating a stand-alone design on the topic *communication/community* first. This was not accidental, as discussions within the team concluded that it would be better to keep the second concept close to power, in order to create better opportunities for emergent functionalities. On top of this, as we chose community to serve as a means to gain insight in power usage instead of seeing community as a separate entity to design for, we ended up designing what can be seen as an emergent functionality before designing a stand-alone concept. In this emergent functionality design, the designed functionality was to set goals with the household in order to create responsibility and accountability for all. In order to set these goals, we also felt that giving feedback on the current usage of the household would be necessary, so that there is a context on the amount of usage.Two concepts were presented for feedback: a table piece that bears resemblance to a board game and a physical interactive bar plot (see Fig. 6).

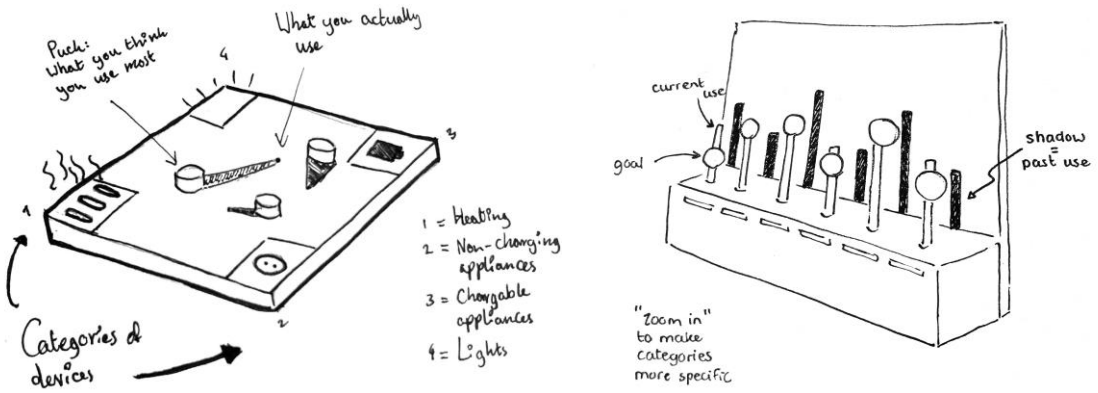

Fig. 6: The table piece concept (left) and the interactive bar plot (right)

The table piece is characterised by being a centrally located discussion piece, designed to engage the community in a similar way a board game would. The concept allows the users to place pucks on the board that set goals for usage of power in user-specifiable categories. The board also provides constant feedback on actual usage in the form of a display underneath the pucks, which creates a shape connecting the actual usage with the puck. Limiting this concept is the feedback of the actual usage, as it is just one point in time or one specific average that can be displayed. Moreover, we felt that the information on use lacked context to give the users richer feedback on their behaviour.

The physical interactive bar plot allows to set goals on user specifiable usage categories, while concurrently viewing current and past usage. The bar size represents the current use, the circle on the bar the goal and the shadow the average (avg. of 7 days) of the past usage. The user can also zoom in and out on the bottom display on the device to see more top-level or more specific categories in which they can set goals. Although we liked the granularity of usage insights, the design felt too much like a physicalization of information, threatening the engagement of the users especially when it comes to long-term use.

As mentioned before, these designs represent more of a concept with an emergent functionality of Watts Down rather than being stand-alone designs, since they make use of the data that Watts Down provides. Based on feedback, it was decided to use the aforementioned designs as a loose representation of the final emergent functionality and to now explore what the core functionalities of the second design exploration would be. Although this appeared to be simple at first, it proved to be quite difficult to let go of power as a topic and to design solely for community. The scale of the latter topic seemed to inhibit the ideation process when we first brainstormed on the core functionalities. The idea in the back of the mind that emerging functionality with Watts Down needed to be present in the final concept may also have hindered creativity at this stage. To overcome this, we decided to constrain the data stream to design for within the home. This also made sure the design would stay within the brief of the course, to design "... a living room IoT device ..." (Frens, 2021). For it to be considered an IoT device, a data stream that is relevant to the inhabitant would need to be present in the design.

After brainstorming on possible data streams, it was agreed upon that water would fit best, as this data stream is invisible yet impactful for bills and climate, tying in to Watts Down's goals. Every team member made one more final sketch of a concept which incorporates water usage as data. On top of this, the following criteria were created by us to further select the design: it should allow the community to set goals on or discuss this data. The design should stimulate conversation, should be interactive and should invite the users to be engaged with the device in the long term. From these sketches, the final design was created in discussion amongst all team members. This concept is named Flow (see Fig. 7).

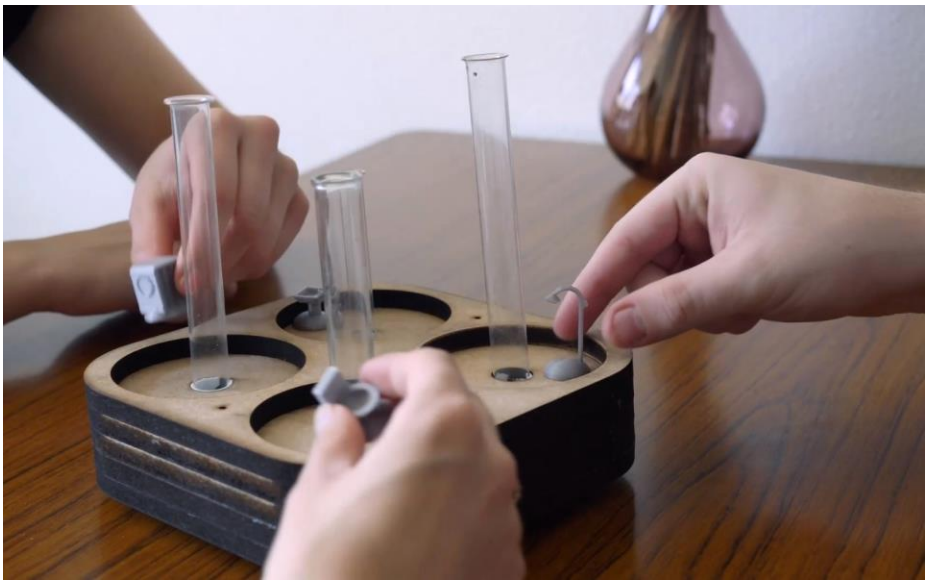

Fig. 7: The prototype of the second concept, Flow, in use

Flow stimulates the conversation of water usage within a household. It is a table-top piece which displays current water usage throughout the week. To increase the community aspects, goal-setting possibilities were implemented with the availability of different tube sizes. Each tube is marked to represent a category of appliances. Several options for the indications of different categories, such as text, icons and natural mapping (Djajadiningrat, Overbeeke & Wensveen, 2002), were explored. It was decided to use phycons to allow users to easily move the categories around. The size of the balls in these tubes indicates how much water has been used at a time to visualize more detailed information. If the goal is not met, it becomes obvious as the tube starts overflowing. This was designed to cause commotion amongst the household members, which leads to discussion.

The pros of the Flow concept are the following: it was designed to be a multi-user interface as it creates a level of awareness of others' actions and intentions in discussion as well as creating a high level of control over the interface (Yuill & Rogers, 2012). The fact that the user can apply the locations and sizes to the tubes themselves, makes it complex but in a playful manner that allows for discussion. Moreover, these phycons are open and playful, again fitting to the idea of a table-top discussion piece. As it is persistent in the periphery, it becomes more useful than an app since the user can look at it in one glance.

However, one could argue that throughout the week it can represent a physicalized dashboard application. The visualisation can provide real-time feedback that can give impulse to change behaviour, but apart from this, all interaction happens when goal setting or reflecting at the end of the week. Moreover, the phycons can spark questions like: 'Which faucet contributes most?' and 'What happens if there are multiple faucet phycons?'. Finally, it can be odd that, where with Watts Down the interaction is very localized and in the moment, Flow is the opposite; centralized and reflective. Although this is intentional (see *Discussion*) it does spark the question why we chose to make these concepts opposite in this manner.

Design exploration 3 - Emergent functionality

The final design exploration was focused on the creation of an emergent functionality. This design emerges from the core functionality (Frens et al., 2018) of both Watts down and Flow. The junction of these concepts tackles both community and power. It aims to generate awareness around power usage, whilst facilitating discussion. This created a design that is meant to trigger communication, by being a centralized discussion piece (as concept 2), now focused on power usage. Whilst also utilizing the form and interaction of concept 1. In this design, it was explored in what way it could use and combine the form, function and interaction of both concepts to achieve this goal. By designing for community, as mentioned in the background, the goal around power awareness of Watts Down could be expanded from individual to a shared responsibility.

The core functionality of concept 2 is setting goals and categories and visualizing the usage. Thus by transforming this to power instead of water, it would be possible to give centralized feedback on a decentralized system. Just like concept 2, this could trigger discussion through data and goal setting, only now on power usage. With the emergent functionality, we wanted the relation between form and function (Frens, 2006) of the centerpiece to remain. This means that the result of action, for instance choosing tubes and the consequential overflow, remains unaltered. So the user can set their goals by choosing the tube sizes for energy usage and if the consumption is higher than the set goals, it would be represented with an overflow.

However, this would require a way to create a logical shift in Flow from water to power; something that could convey clearly to the user that it is representing power now and not water. It was decided that this was something we wanted users to have an interaction for, so that it will be a conscious shift. By literally connecting both devices, Watts Down and Flow, it would create a clear signal on its current state. The table-top piece contains a socket to which the Watts Down can be plugged into. The interaction of pushing the Watts Down in the Flow block supported this signal, creating a new interaction. One that emphasizes that water is no longer displayed, but instead it is energy usage. Strengthened by the balls turning from blue to yellow. This contributes to the clarity of emergent functionality, as it requires a conscious physical activity form the user. Through the adaptation of Flow to facilitate plugging Watts Down in, we unite the separate systems and create a central point for a decentralized system. This central point was in our opinion the best way to facilitate discussion as it brings people together. The parameters of use (Frens, 2006) of our design are meant to push the user into conscious decision making, that is setting the goal tubes and pushing the Watts Down, making the shift from water to energy.

However, we thought this interaction could be improved, as plugging just one Watts Down in does not really make sense. Besides to visualize the shift, which could also be done in other ways, the Watts Down would lose its function. Yet the form of the Watts Down inherently allows the user to stack them all. Once stacked the adapters accordeon can be pressed down. The friction is still representative of the consumption of power as in concept 1. Thereby this interaction is meant to embody the transfer of energy and data from the adapters to Flow. The tubes in Flow will in turn fill up with yellow balls. This induces a reflective moment, where the goals can be compared to the actions, which is familiar from Flow. Furthermore, this emergent functionality even expands the parameters of use (Frens,2006) for the Watts Down concept.

With this design, once a week the Watts Downs should be collected and the household is stimulated to gather and watch their weekly energy usage fill the tubes, discuss the results and set new goals for the week (Fig. 8). This would mean that during the week the two designs, Flow and Watts down would be completely disconnected, and that the user could only get periodic feedback. Therefore it was desired that even if decentralized, the two would still be visibly connected. The information-for-use (Frens, 2006) given by the breathing motion of the current usage from concept one, can also be visualized in the emergent functionality. This provides the two systems to be visibly connected and the information to be both centralized and decentralized accessible. Thus, during the week, the table piece will visually display the current power usage by mimicking the breathing of the Watts Down's within the tubes with bouncing yellow balls. The magnitude of the bounce is mapped the same as the breathing representation. If a lot of energy is currently being used, the breathing and bouncing is heavier, giving the user continuous feedback.

Fig. 8: A household discussing the results of their weekly energy consumption

Some of the pros of the emergent functionality are the same as concept one and two, as this concept emerges from those designs. For example, the goals setting from the Flow concept is a strong method to trigger discussion. In this concept it supports the discussion on power usage. Thereby the physical effort that is required to be able to push the Stack of Watt Downs in, creates a moment of reflection. The push motion triggers the tubes to fill up, it is the moment to find out how well the household did regarding the goals. This moment could also be viewed as a fun-game like interaction, as the household can gamble and find out how well they did. In the emergent functionality the current usage is represented both centralized and decentralized, creating more possible moments to gain insights. The down side of the combined centralized and decentralized aspect is that the user would be required to gather the Watts Downs weekly. This might be an inconvenient task, that increases the threshold to actually have the weekly reflective moment. Thereby, it does not create any incentive to remind or stimulate the household to have the weekly discussions. For it to actually work, this might be a necessary addition to implement. Furthermore,

the interaction of pushing in the stacked Watts Downs might be confusing as the same action has a different meaning when it is plugged into the wall or the socket.

All in all, the emergent functionality that became available from the combination of Watts Down and Flow created a centralized table piece that allows for communal discussion and awareness of power. The design uses the visual representation of the water usage from Flow and extends it to the abstract concept of power usage. This design exploration allowed us to include two very different concepts and the notions of community and power, into one design.

Discussion

Within this discussion, we cover three main topics that we, through collective reflection, found to be most insightful and educational in relation to designing in the field of rich and embodied growing systems in the home. This discussion can be seen as a transcription of a reflective session within our team, ensuring that each member has provided their valuable reflective input on the design process and overall premise of the elective. The discussion covers the influence of our design process, the specific design choices that we made and how our design explorations fit the bigger picture of rich and embodied growing systems in the home.

How did our design process influence our results & insights?

At the start of the second design exploration, our process was not conducted in a traditional sense. We found it quite difficult to let go of the core functionality of the first design concept, as we knew both designs had to be merged eventually. By 'holding on' to the scope of awareness regarding power as a functionality, we essentially bypassed the second concept and directly designed our emergent functionality. This allowed us to specify our scope for the emergent functionality and second core functionality at the same time, which reduced the complexity of designing for an open system. The result is that our emergent functionality is relatively well defined based on the two given design topics, while the second core functionality feels like it is not a fully standalone functionality as it was designed from the emergent functionality. This has consequences for both the openness and interaction of Flow itself, which therefore remains as a concept for generic data visualisation and goal setting.

Arguably, the design of Flow is thus more closed than it would have been if we had designed it without Watts Down and the future emergent functionality in mind. It allows for growth of the system, but is limited in this regard by the physical connections and interactions. It can theoretically connect to devices digitally as well as physically to visualize data streams and allow for goal setting, but implementing this meant limiting the potential for rich interaction as each interaction had less specific meaning. This highlights the challenges of unifying the rich interaction paradigm and growing systems. The need to balance these aspects instead of trying to have maximum amounts of both elements therefore became clear from this design process.

In terms of discussions and brainstorming. Our discussions were extensive and detailed with a plethora of arguments for each conceptual decision, however this led to our group running in circles quite often, prohibiting us from further exploring for example rich interaction possibilities. While this made sure that we had a strong basis to build our design upon, our designs remained

abstract, lacking well-defined form and interaction. During later stages, we attempted to address the elaborate discussions and abstractness by setting time limits and well-defined goals for each session. This helped immensely in designing more fruitful concepts and generally stimulating progression.

What are our thoughts on the design choices made for each concept?
We feel that our decisions on designing for either a centralised or a distributed system depends heavily on the goal of said system. Specifically in the second design case, the brief of designing for community/communication meant that the selection of a distributed system followed organically. This is because we saw our challenge in case two as designing for creating debate within a household, instead of, for example, creating community/conversation by connecting people remotely such as in a forum.

With mapping, we found that multiple ways of mapping lie on a spectrum from abstract and flexible to concrete and contextual (see Fig. 9). When reflecting on our designs, we found that Flow was more abstract than Watts Down, but that also meant that it could be used for several data streams. On the other hand, Watts Down was designed for a very specific functionality related to the power socket, which made it harder to repurpose this design. Therefore, we believe that we explored different sides of the spectrum with our designs.

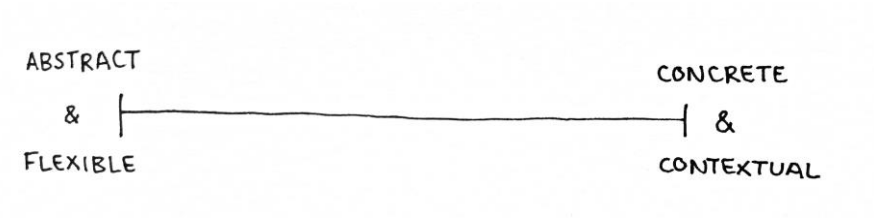

Fig 9. : Spectrum between abstract & flexible to concrete & contextual

We found that this spectrum could also be applied in the context of the Flow design, regarding the use of phycons. We believe that these were a good compromise, since they are flexible enough to be utilised in any users' house but still provide enough context for the users to understand the mapping. However, as stated before, it was a compromise, as for example, the designed phycons do not distinguish between different taps. A note written by the inhabitants themselves would be an example that is more flexible and thus allows the user themselves to map the system. This would however impose issues on the design side as the system needs to cope with this flexibility and somehow properly assign the tubes to the handwritten notes. Moreover, we specifically wished to keep some abstraction in the mapping, to make the goals more interpretable and discussable with the household, this further established that phycons would be a compatible mapping for Flow. To us it also seems that the choice of mapping also has implications that we did not fully design for. An example of this is that the phycon can have a connotation of a play piece on a board game but can also create the implication that people want to further customize these phycons. Our current implementation is not making use of all these implications, but they do show the potential for interaction possibilities with phycons in our design.

How do our design explorations fit in the bigger picture of the smart home?

Our overarching goal of the several design explorations was to design for sustainability. In terms of ‘form, function and interaction’, due to the relevance and realism of this goal in combination with our collective experience through other design courses, we notably started our iterations from a functional perspective. Approaching the design challenge from this rather ingrained perspective led to us finding many difficulties in meaningfully adding in the other two aspects of form and interaction (Djajadiningrat et al., 2004). This meant that in order to broaden our perspectives, we had to let go some of our preference for realistic feasible design, which proved to be difficult for some more than others and lead to great in-depth discussions. Doing this however proved to be quite constructive for the remainder of our design process, where learning opportunities through debate took precedence over constructing a technically feasible product.

In terms of scaling realistic to futuristic, our two design concepts and the emerging functionality do not appear to fit in either category very well. Our concepts lack definition for underlying technology such as necessary sensors, actuators and available IoT networking data. We do think that the emerging design for interconnectedness by combining a physicalized form of data visualisation with conversation-stimulating design in the form of a centrepiece does possibly have a place in the smart home of the future, perhaps if the device is open-ended enough to allow it to grow as a system itself. Our concept however more-so fits in the category of abstract design; aiming to, through the iterative process, offer us many learning opportunities on how to combine form, function and interaction in meaningful ways.

Conclusion

The smart home with its internet of things devices is an interconnected system consisting of many products. With the current technology it has the potential to grow to an even greater complexity with more and more products. Three designs were created to explore rich interaction in the smart home context, to see whether these designs could help users gain awareness and insights in normally abstract consumptions like power and water.

The first design called Watts Down was designed to create awareness on power consumption. Watts Down required the user to actively invest physical effort to connect the adapter to energy, which, combined with the haptic and visual feedback, results in a reflective moment. The second design called Flow was designed to create communal awareness on water consumption through displaying the water usage and allowing the household to set goals and categories. Lastly, the emergent functionality was explored. Through combining Watts Down and Flow, a discussion piece on power consumption was created.

The design process to reach these three designs was a bit different than conventional. We experienced challenges to let go of some ideas or notions and did some backwards designing. This resulted in extensive discussions and designs that have a well-defined scope, but also perhaps limited potential, as our second concept was designed with the third concept in mind. The designs on some level lacked well-defined form and interaction. One of the things that we experienced trouble with was realism, as our designs lack definition regarding sensors or required technology. However this was needed for us to be able to integrate form and interaction as well as functionality.

To conclude, we believe that there is a place for rich interaction in growing systems if: complexity is handled well, the premise of a growing system is balanced with the rich interaction paradigm as well as possible, and a bridge to reality is made. So yes, but… It depends.

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Appendices

Reflection - Iris Bataille - 0997080

At the start of this elective, I already had experience with designing rich embodied growing systems within the smart home context from my M1.1 project in the DIGSIM squad. Since this direction fits my interests and vision, I wanted to gain more experience in designing such systems. During my M1.1 project, I realized that because of the complexity such a design challenge can bring, I tend to make decisions that feel logical to me, but are sometimes not the best option. I believe this can be solved by providing clear arguments for decisions. Therefore, my goal for this course was to focus on making well-substantiated design decisions while designing growing systems.

Looking back at this goal, I can say that our group dynamics helped me to reflect on the decisions that I made and the reasons behind those decisions. Because of the different perspectives within our group, many discussions were held about our designs and the reasonings behind it. From these discussions, I learned how to clearly explain my ideas. Next to that, the literature that we read helped me to find academic support for certain decisions. So by putting emphasis on the decision making process, I learned to develop and reflect on reasoning behind decisions.

Another thing that I learned from our group work is how to deal with complexity in the design process. During our discussions, we often kept going in circles because of the abstractness of our ideas and conversations. Later in the process, we tried to solve this by keeping track of the decisions that were made already and using sketches to have concrete things to discuss. This helped to look forward. I learned that in a complex and abstract design case, it is important to start making things concrete early on.

I learned several things about designing emergent functionalities. Looking back at our design process, I realize that we designed the second concept with the connection possibilities to the first concept in mind. This resulted in a narrowed-down design case. I learned that it is hard to create openness for the unknown, which is why we held onto the first design concept. However, it would be interesting to see how our design would have differed when we let go of the first design.

I also noticed that by making a design that is open for growth, the design and interactions became less specific to the functionality. Our Flow design is a good example of a ‘general’ design that can be used for multiple functionalities. This was very interesting to me, since this relates to my current research project, in which I explore the possibilities for one design that is specific for multiple functionalities.

So to conclude, I learned several concrete things to keep in mind during the design process, such as the importance of making abstract ideation concrete and to let go of self-constructed constraints when designing for growth. I believe these insights are important and useful for my current research and other future work.

Reflection - Lars Giling - 0944466

I chose to follow the course A Designerly Perspective on IoT for two reasons. The first reason is because I am interested in designing for the smart home as a growing system, with the second reason being that I find interaction design quite interesting in what it's trying to achieve with bringing habitual interaction of users into design. In previous projects, I have (in my opinion) failed to adequately explore the spectrum of interaction design in order to embed it into my designs in a meaningful way, and through this course I noticed that there was even a far wider amount of possibilities in this realm of combining form, function and (meaningful) interaction.

I feel the course structure was rough, with several new exploration and iteration steps crammed into a single quartile. However, through doing these explorations and iterations in combination with well organised and motivated discussion moments both with the entire course as well as in our own project group helped me gain a better understanding of the many approaches in rich interaction design for growing systems. The literature was well structured, and instead of just acting like 'background literature' which often feels the case in other courses, it actually brought widespread support in my/our iterations and was widely discussed as to where we find ourselves as designers in terms of preferences for certain interaction design styles. For example I learned that I much prefer parameters of use, while I seem to advocate technology parameters. Through the literature, discussions and by experiencing this, I can now better motivate design parameters.

Lastly, I want to address our team mentality and progress. It was clear that everyone in our team was very eager to learn, and it was great to see how different members took different stances on topics of interaction design and growing systems design, leading to meaningful and interesting debate. We did however find it difficult to advance through design iterations, often running in circles because of flaws we found in concept discussion rounds. I felt like I was partially to blame, as I found it difficult to step away from the aspect of function and seeing it as something that should actually be fully working and deployed, therefore dismissing interesting form and interaction possibilities due to it 'not going to work'.

Later on, as we explored more from the perspectives of interaction and form and grew the concept from there, I was able to better adjust myself in the debate, which ultimately helped us conceptualize more meaningful designs, even if the design itself remained relatively abstract. I therefore look back on this course not as a design challenge, but as a learning process, where through debate and exploration, I learned to put into practice the theory of interaction design for growing systems. I would like to thank my team for their great motivation and joy they brought into this course, making it one of my most enjoyed and constructive courses so far.

Reflection - Sebastiaan van der Kam - 1233564

My selection for this course for two main reasons. The first that this course provided a great opportunity to explore Rich Interaction further, since implementing Rich Interaction is the main goal. Secondly, I have a love-hate relationship with IoT and for that reason I want to explore the domain further.

Since I was already exposed to quite some Rich Interaction theory in Cardboard Modelling and quite a few growing systems theories at DIGSIM, I came into this elective wondering how much theoretical knowledge I would gain. However, what I learned is that by using the theory in practice within a group, it means that you need to be able to argue the position you take better. The fact that our team was prone to debate design decisions was valuable to me. The main learning point I take from this is that, especially in a Covid situation, I should sustain these design debates, to better explore what theory means to my practice.

For me, Rich Interaction as a process was tied to making cardboard models, partly because Cardboard Modelling was my first exposure to these principles. Now, we worked by debating on design, so verbal instead of making. This was partly due to the online format and partly due to the large group. Even though I would still favour ideation through making, I found value in the abstract conversations brought by debate as previously stated. However, I did find that this way of designing is prone to moving in loops where you argue the same point multiple times. I learned that if you design through a lot of debating, you need to make requirements and definitions very clear before starting the discussion, as well as take clear notes of conclusions.

The example of the Albert Heijn Self-Checkout is a great example of how the mentality of Rich Interaction can be implemented in cost-effective, mass produced devices. It is inspiring to me as someone who finds the tension between digital and tangible interactions intriguing, and shows me the value of Rich Interaction as a mindset even when the result looks very different to concepts designed by students. Yes, the design projects by students can be easy to dismiss as unrealistic but I believe the intentions behind the designs can be very valuable and refreshing. I do believe the mindset can be very beneficial in the commercial space.

Do I believe there is a place for Rich Interaction in growing systems? I think the interaction style can add a lot to the experience of use, especially by stepping away from efficiency and exploring values closer related to the home. However, I do not think that changing the interaction style changes my feeling that IoT is a technical solution in search of a problem.
As a designer, I do believe I can aid to shift the field towards a problem-solving approach and in this, I do want to keep the Rich Interaction mindset. My next aim will be to explore Rich Interaction in more commercially viable solutions.

Reflection - Anika Kok - 1508482

This course has surprised me in the positive sense of the word. As a designer, my focus is not necessarily on the smart home or IoT. That being said, I am very interested in Calm Technology or rather: designing for varied levels of attention to limit the burden on our mental capacity to increase focus on important things in life. Previously, I have mostly focussed on screen based design which I now realise limited me greatly. I thought of design as: 'Design should (help) get the job done'. Through this course, I realised that design can be much more. My mindset has gone from: 'How can we solve the problem fast and efficiently?' to a higher level way of thinking that pushes the standards and puts the user even more at the center of attention when designing (the interaction with) products.

A lot of the topics, approaches and ways of thinking as discussed in the course were fairly new to me which made me wonder: what does this mean for me as a designer? At university, we are innovating. We are often many steps ahead in comparison to the time and budget constrained commercial world. Let alone the openness with which society is welcoming or more often neglecting innovations as they are new and unfamiliar. Especially when looking at the work field ahead of me, a critical question that raises in my head is: How would this look in business and commercial life?

By following this course, I have found a new interest that I am now attempting to fit into my FMP. I am wondering how natural interaction can play a role besides Calm Technology. Could natural interaction lower the amount of attention that is needed as the interaction is more intuïtive and straight forward? Could natural interaction in the form of for example gestures improve multi-user interaction as it potentially increases awareness of others' actions and intentions? How to design for openness so that the system can grow and improve? I know these questions do not necessarily address rich interaction, but the train of thought has certainly been set in motion.

Lastly, I would like to discuss more of a process related learning point: I think our group really represented my individual design process. By 'being able to see it outside myself' I gained insights that I will use to improve my own work. For example: I love that our group was discussing extensively. I believe it helped us to be critical and come to new realisations. However, I do think it has been important to learn how to limit this somewhat to steer away from abstractness at some point. Sometimes we were running in circles which prohibited us from actually exploring how the design and interaction could look concretely when put to paper. Progressive insight that we used to improve immediately, and that I will continue to use in my future as a designer!

Reflection - Jef Rouschop - 1229926

A Designerly Perspective on IoT is a course I chose for several reasons. Firstly, it offered me a chance to explore interaction design from an IoT and growth perspective, coinciding with my interests in hybrid and modular designs. Secondly, it allowed me to challenge my mixed feelings towards designing for the smart home. Lastly, I wanted to explore further how literature could be used during the design process.

Traditionally, literature feels like 'an afterthought' to me: I sometimes look at it during a design process, but rarely use it concretely until the point writing the report. In the past eight weeks, I therefore tried to remain engaged with literature. This approach was successful, as I feel it has made for more theoretically grounded designs. This practice helped immensely in clarifying (tangible) interaction concepts as illustrated in the final report. However, I also realized that theory has limited use: later in the process, the use of theory kept concepts abstract and felt inhibiting, which was why it was let go of a bit. The role, strengths, and weaknesses of literature became clearer to me, yet I do think there is no 'right' method of use.

Past experiences in designing for the smart home left me with mixed feelings. Many current smart home devices and concept designs are interesting interaction-wise but feel unnecessary, just focusing on convenience. By following this course, I challenged myself to see whether smart home design could also relate to more interesting opportunities. Designing for awareness of, discussion on and action on elements of the home were new facets of the smart home which proved to me that there is room for designing for other purposes than convenience. However, their necessity remains arguable to me and should be explored in the future.

The interaction design possibilities were the most interesting part about designing for the smart home. In this regard, there were several interesting things I learned in this course. I discovered I tend to mainly think in technology parameters instead of parameters of use. This was highlighted by the data-centric view I had during brainstorming on how to connect our designs to other devices or parts of the home. Resulting from this were mainly centralized visualization designs reminiscent of IoT dashboards in apps, a tendency which I tried to change this by looking at more local, distributed designs (specifically for Watts Down) that invited more tangible interaction. Much of the mandatory interaction design literature and group brainstorming helped to break this pattern, although the results are not as interesting from an interaction perspective as they could be (aside from being a bit unrealistic).

Lastly, designing with this many requirements was quite challenging for my group and me. We sometimes got us stuck thinking in circles until we temporarily let go of one. I doubt that all requirements of this challenge (growing systems, rich interaction, IoT) are unifiable in (smart home) design. Nonetheless, it provided a great learning experience and remains interesting to think about.

Reflection - Daphne Vermeer - 0936570

This course for me was crucial for the learning goals I have set for myself and what I want to learn during my master. In my master I intend to specialize in C&A and T&R while following the RDD track. These skills, I believed, were something I lacked knowledge of and had a lot of room to grow and develop.

The framework of rich interaction, for me, was an entirely new way of viewing design. The principle to not only design for the cognitive skills, but also make use of emotional and perceptual-motor skills is a very interesting and more inclusive approach. This actually has strong ties with my personal view and previous education. I am very holistic focused and I like to design for better (richer) experience, taking my knowledge of social psychology into account. From this course I learned how to implement rich interaction in design and to not view function as more important than form or interaction. I actually think this framework can offer more depth to a design.

Although, I do believe that in our process we sometimes lost sight of form and function. As there were many requirements to the assignment and we added own criteria, like sustainability, it created a lot of complexity. We had countless discussions and the tendency to stay in abstraction, resulting that we sometimes got stuck. However, this offered a great learning experience, as it is important to prioritize criteria and make concepts concrete to get out of the abstraction. For instance, with the second design I experienced difficulties to let go of the concept of power. I believe that when I managed to do this, this lifted the overall designs resulting in more unexpected outcome, less close minded vision.

I used to believe that the best way for design is if everything was integrated from the start. But this course showed me that design that is open for growth could also be achieved in other ways. Our design process helped realize this, we jumped with our second concept immediately to the emergent functionality, which is something I would intuitively do. However, while working on the project I saw the strength in taking the step back and letting go of certain ideas. This helped to design a second concept, after which the third could emerge from the other two designs.

During discussions we sometimes went in circles and I believe the vision on rich interaction sometimes got lost as we got into our habit of thinking more about function and less of form and interaction. This taught me of the pitfall that easily happens as designer, with constraints (requirements or time) we sometimes fall back to what we know instead of keeping the open approach. However, these discussions were constructive and we managed to get out of these pitfalls. The extensive debates and critical views of my team helped immensely to think more and further about the topics and the implications of design choices. It provided insights and different ways to approach things, to not just settle for something but think about all aspects and what it would mean.

This rich interaction approach is something I want to apply more in the future. Such that I can get more familiar, to keep this inclusive thinking on design and rich experience design.