Teaching Alternative Paradigms through Critical Design

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Abstract. This paper introduces and reflects on a master elective course for Interaction Design students titled Researching the Future Everyday. Aiming to equip students with the skills to critically adapt their own practices to the changing societal roles of design, the course guides students through a critical design approach with three key elements: a Science and Technology Studies paper that provides an alternative paradigm for assumed relations between design and societal issues, a Critical Design approach that makes the paradigm relatable for designers, and the use of Research Products to stimulate generalization of design implications beyond the exemplar. By analyzing ten student projects, we identify two patterns of using critical design to extend and enrich alternative paradigms. One uses oppositional designs to develop alternative design approaches. The other uses accelerational designs to extend alternative problem spaces. These patterns and their variations reveal avenues to further support students in developing critical practices.

Keywords: Science and Technology Studies; alternative paradigm; future everyday life; Interaction Design; Research Products; Designing to Know.

1 Introduction

> "*Caught in the headlights of a global death spiral, many students become overwhelmed by the sheer complexity of the world, where "doing good" or designing anything to have a positive impact seems futile or impossible*." [1]

The role of interaction designers in society is changing. Climate change, loss of biodiversity and growing inequality pose daunting challenges in which technological innovation plays a complex role, both as part of problem and solution [2-5]. As illustrated in the quote above, design students can get paralyzed by this situation. Yet other students do not make the link between their aspired profession and the causes of societal issues such as climate change and inequality. To gain better understanding of and grip on the complex and dynamic relation between the design practices they are

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training into and societal issues, interaction design students need to gain an ability to continuously question and pro-actively adapt their practices.

Questioning one's own practice requires critical thinking – one of the three primary 21st century skills [6], including what Nickerson [7] refers to as the ability to 'question one's own views and attempts to understand both the assumptions that are critical to those views and the implications of the views'. While criticality is an integral part of design education [8], questioning such basic assumptions is not easy. These assumptions are often implicit and therefore hidden. Even more difficult is revealing hidden assumptions within one's own community. As well phrased by social research scholar Hockey, '[t]hat which is closest may well be that which is most difficult to see' [9]. The more widely shared an assumption - e.g. 'technological innovation solves societal problems' - the more powerful it is in holding a practice together, and the more difficult it becomes to change. Such assumptions that are fundamental to a profession can be viewed as paradigms. Paradigms are defined by Kuhn [10] as 'sets of conceptual and instrumental tools', which both enable and restrict activity, including the ways in which phenomena are approached and observed. Paradigms are useful, and in complex fields like design, essential for the practice to function. In the words of Brad-Wary, with the help of paradigms 'one is not overwhelmed by a torrent of extraneous information as one seeks to understand the phenomena that are the objects of one's study [or design activity]. One sees what one should see' [11].

However, a paradigm is by its nature at the same time restrictive. To illustrate the restrictive character of paradigms, Merten [12] uses the example of the concept of crime, which tends to be associated with lower social status, but if approached strictly to refer to the violation of criminal law, white-collar criminality is included, and a different picture emerges. While different paradigms can exist next to each other, particularly in a 'pluri-discipline' [13] such as design, they tend to be incommensurable [10]. Shove [14] specifies this aspect of paradigms by pointing out that a particular paradigm or perspective on a problem not only leads to different solutions, but importantly, also leads to a different framing of what is seen as the problem. Put more strongly, what is considered a solution in one paradigm can become the problem in another.

While a paradigm shift [10] is required to escape design's current role in the causes of societal crises, teaching students to make a paradigm shift implies tearing down fundamental, yet often implicit structures they have developed to cope with the complex playing field of design. Understandably, this can be paralyzing when the alternative doesn't have clear implications for design practice. In an attempt to overcome these challenges, we have designed a course set-up for interaction design master students that integrates three main elements: critical theories from Science and Technology Studies, Critical Design and Research Products. Below we elaborate on these choices and position the course within existing work in interaction design.

2 Related Work

Design as a profession and field of research is not static. Over time it has adjusted with its changing role in society, and proactively steered itself in new directions [15]. For example, the focus of design and research activity has shifted from function, to usability, experience, inclusivity, systems, and transitions. In the field of Human-Computer Interaction (HCI), major paradigm shifts have been identified as waves [16, 17]. In part, these waves have been responses to the changing role of design – for example, shifting from a focus on workplaces towards domestic settings – but critiques from other disciplines have played an important role here as well. For example, the influential work of Suchman [18] complexified the focus on lab based usability studies towards studying interactions 'in the wild' as situated action, Similarly, Latour's notion of placing artefacts on the same level with humans as actors in Actor-Networks [19] has broadened the unit of design, Akrich's notion of script [20] has reconceptualizing the designer's agency in situated action, and social practice theories formed a basis for a set of novel interaction design approaches [21].

2.1 Science and Technology Studies

Work from these other fields, broadly placeable under the banner of Science and Technology Studies (STS) has proven a fertile ground for paradigm shifts in design research. This is understandable for several reasons. STS scholars are generally not part of design's communities of practice and thus better positioned to identify shared assumptions. Also, sub-sections within STS specifically focus on critiquing relations between technology and societal change and thus have design practices as part of their focus, and third, STS scholars are trained to critically identify hidden assumptions.

As Bardzell and Bardzell explain, critique is a learned skill. It requires skepticism, which they define as 'a suspicion that social reality is not what it seems but rather that something else quite different is going on underneath its surfaces'. As such, the role of the critical theorist is to 'expose these hidden forces', which then forms the basis for an alternative explanation of social reality [22]. In other words, criticism is a learned skill, and identifying hidden forces underneath the surface requires time and dedication. Fortunately, the work of trained skeptics becomes available through STS and related publications in the form of critical social theories, such as those referred to above, along with the identification of implicit ideals such as capitalism, neoliberalism and techno-optimism.

A recurring pattern in this work is that relations between technology and effects in everyday life are explained using a theoretical lens that is critical of the mainstream or dominant perspective on this relation, and highlights a problem where mainstream perspectives see a solution. For example, questioning the mainstream assumption that energy saving technologies contribute to reduced energy use through improved efficiency, Strengers [23], taking a practice theory perspective and based on ethnographic work on energy technologies in everyday life, argues that because these technologies embody and legitimize assumptions of unsustainable lifestyles, such as drying clothes in a dryer instead of on a line, they can have opposite effects.

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These critical theories can form a basis for paradigm shifts in design. However, while critical STS publications can work to engage students that had not considered the types of unintended, often undesirable effects that technologies can have in society previously, the problem remains that these studies can be paralyzing for designers. A characteristic of STS studies is that they tend to critique technologies' effects in hindsight, long after the influence of designers in the lifespan of these technologies seizes. They thus offer little in terms of actionable insights for interaction design. Moreover, they tend to stem from different disciplines – anthropology, sociology, environmental sciences, geography – that can be difficult to access for designers due to different vocabularies and assumed background knowledge.

2.2 Bringing STS into Design Education

STS has informed many paradigm shifts in design research, but it is less common to find literature on STS in design education. Without claiming completeness, we present two examples.

Ward and Wilkie [24] describe a course set-up in which they explore how Latour's Actor Network Theory 'can be fruitfully utilized within the teaching of design processes'. They present two examples: Mapping Societies and Mediating Futures. Mapping Societies acknowledges societies, or assemblies as a material for design alongside more traditional techniques. This workshop aims to teach students qualitative social research methods such as diagramming relations within and between actors, entities, claims and so on, inspired by ANT, i.e. map societies as actor-networks and include a more diverse range of 'actors' than they normally would. Next, the students re-script the assemblies through designerly interference.

Mediating Futures guides the students through projecting facts into diverse and unusual future worlds and represent everyday details through film, drawing and montage. While building understanding of their complex playing field through these new methods, the outcomes of this second workshop served to provoke publics into questioning current values and practices.

Von Koenig [25] asks how to teach design history in a way that adds to students developing as critical designers. From her analysis of design history courses across design programs in the United States she concludes that 'design oriented assignments' with open-ended, problem based provocations to respond to selected readings, and linking the historic studies to contemporary issues resulted in more critical engagement than formats in which students were asked to simply 'learn the facts'.

Both courses weave theories from other disciplines into design education through design activity; the first mostly offering methods based on ANT, the second being more open-ended in offering the 'alien' material as inspiration for design. Building on these practices, we turned to critical design practices to facilitate the students in engaging with the STS material.

2.3 Critical Design and STS

Critical Design [26, 27] groups together different design practices that, in contrast to Affirmative Design do not adhere to the conventional, mainstream purpose of design to work towards products for the market. Critical Design is a set of design practices that could be helpful in achieving the aim of making alternative paradigms actionable for design. As Helgason et al. [28] state:

> *'If applied effectively within an educational setting, the processes of creating speculative objects and narratives can encourage interrogation of prevailing assumptions and invite exploration of other, alternative states of being and doing'.*

However, critical design has been critiqued for its failure to 'challenge the broader reasons for the problems that we face', focusing on "downstream" problems of capitalism without offering a position on structural inequalities and problematics' [1]. Combining it with critical theory may offer a way to circumvent this shortcoming.

STS and Critical Design are no strangers to each other. However, the dominant tendency of work in this area is to use critical design to 'engage publics' [24] and 'generate debate' [29] around the role of science and technology in society. Intimate Futures [30] for example, presents two Design Fictions, AYA and U, that build on Haraway's notion of Staying with the Trouble [31] in combination with STS work on the role of technology in domestic abuse and discrimination against women. Both designs are presented in an open-ended way and mainly meant to trigger discussion and raise question.

Other critical design work is used as a tool within STS to make complex scientific developments accessible for public debates around science and technology. For example, within the Material Beliefs [32] project, Elio Caccavale's Neuroscope, and Natalie Jeremijenko's Feral Dogs allow a different form of public engagement with science and technology through speculative designs and events. Similarly, Auger et al.'s Carnivorous Domestic Entertainment Robots [33] provocatively explored the emerging technology of microbial fuel cells with the objective of highlighting controversies and stimulating debate.

Our aims are directed at facilitating the shifting of paradigms in design practices, making designers the main audience: to gain insights through design, for design.

2.4 Material Speculation

This idea of using design not as a means of engagement, but primarily as a means for inquiry is central to Material Speculation [34]. In this critical design practice, artefacts aren't necessarily brought into a public realm, but primarily form means for 'critical forms of knowledge production' by situating them in everyday life. Odom et al. offer a number of criteria to which such artefacts should adhere to make them suitable for investigating 'complex matters of human relationships with technology over time in the intimate and contested contexts of everyday life' [35]. Within this area of research, the idea of Research Products emerged. Research Products [35] should have characteristics of 'independence' and 'finish', which enable 'deployment' in everyday

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settings, which in turn stimulates a focus beyond the specific artefact towards the role of technology in everyday life. Moreover, the focus on 'fit' and 'inquiry driven' stimulate the use of the artefact as a vehicle for knowledge generation rather than a mere provocation and an end. We assumed that these clear guidelines are helpful for students to work with this otherwise relatively unfamiliar form of using design.

In the following, we first introduce the set-up of a master elective course, titled Researching the Future Everyday, that we designed on the basis of the elements introduced above. In summary, these are (1) an STS study introducing an alternative paradigm for understanding the role of design in social change, (2) a critical design approach to explore 'alternative states of being and doing' [28], and (3) a requirement to produce generalizable knowledge outcomes. We offer ten project descriptions as illustrations of outcomes and reflect on them to evaluate what kind of learning emerges. The framework we developed through these reflections could be helpful for others aiming to teach interaction design students alternative paradigms through this or similar teaching set-up's, and highlights next steps to achieving critical thinking skills in interaction design students.

3 Set-up of the Researching the Future Everyday Course

Based on the principles introduced above, we designed a new master elective course in 2018 titled Researching the Future Everyday. The course design forms our answer to the question how to expose students to alternative paradigms concerning the role of design in societal change, and facilitate them to engage with, explore, apply, evaluate and generalize this paradigm, through design, for their own design practices. Table 1 offers an overview of the three elements and how they were implemented in the course design.

Table 1. Overview of different elements in the course and their objectives.

Element	Reasoning/objective	Manifestation
Alternative paradigm	In-depth questioning of assumed relations between design and societal change with alternative paradigm from STS that is relatable through practical examples	Working with one carefully selected Core Reading and re-reading it several times throughout the project
Critical Design	Translating the alternative paradigm to a designer's action space without the aim of market success	Explore 'alternative states of being and doing' in future everyday life, supported with Future Probing and role play techniques
Material Speculation	Using Research Products to generate generalizable knowledge applicable beyond the specific project	Use the design to collect data in a deployment. Reporting the project and its results as an academic knowledge contribution in a paper format

To offer some background to these considerations it is important to explain that the students in the Industrial Design programme at Eindhoven University of Technology are taught a combination of Interaction Design skills and theory such as electronic circuitry, sensors/actuators, data science and basic programming as well as design. They learn different design approaches, from user-centred design to more system approaches, creative techniques, interaction, aesthetics, and various physical prototyping skills. One of the compulsory courses in the master programme titled Constructive Design Research focuses on using design as a means to generate new knowledge.

Figure 1 offers an overview of the course elements over time. These elements are further explained below.

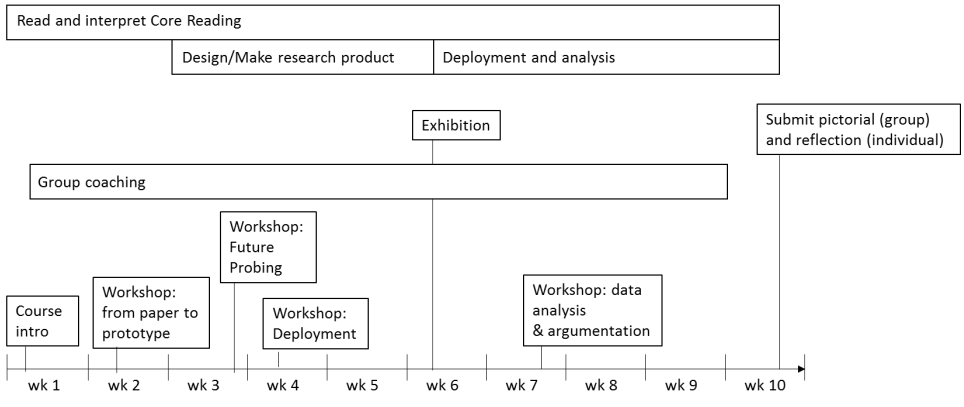

Figure 1. Schematic overview of the course and its elements.

In the course, teams of two to four students select from a list of STS studies provided by the course conveners one paper, referred to as their Core Reading, which forms the basis for making a Research Product [35]. The Core Readings represent a curated list of empirical STS research papers that critically interrogate mainstream assumptions of the role of technologies in society. The Core Readings do not offer implications for design. Instead, they critique a basic assumption about the relations between people and technology – which we hereby refer to as the "conventional paradigm", using an empirically illustrated critical theory, referred to as the "alternative paradigm" (see table 2). Beside the Core Reading, students do not receive general introductions into STS. The course conveners that coach the students in their projects all have intimate experience with both STS and critical design.

Table 2. Core Readings, the conventional paradigms they critique, their alternative relational paradigms and names of student projects that built on them.

Core Reading title, authors and year	**Conventional Paradigm**: The basic assumption about technology – everyday life relations	**Alternative paradigm:** The alternative perspective on the technology – everyday life relation illustrated with empirical data that presents	**Project Names:** Student's Research Products

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	that is critiqued in the Core Reading	and alternative problem space	that build on Core Reading
"*The industrial revolution in the home*." Schwartz Cowan, 1976 [36]	The industrial revolution in the home relieves women of household labor	The industrial revolution in the home has not led to reduction of housework due to societal developments such as remise of domestic servants and increasing standards of cleanliness resulting from new technological capabilities	Laundry Buddy
"*Screened intimacies: Tinder and the swipe logic*." David and Cambre, 2016 [37]	Tinder is a tool that facilitates social connections	Tinder disrupts and reshapes human practices around intimacy	Aimy
"*By any means? Questioning the link between gerontechnological innovation and older people's wish to live at home*", Neven, 2015 [38]	Assistive technologies help elderly to live at home for longer	Assistive technologies risk diminishing the house as a home	Mister Owl
"*Convenience and energy consumption in the smart home of the future: Industry visions from Australia and beyond*" Strengers and Nicholls, 2017 [39]	Smart home technologies contribute to convenience and improve energy efficiency	A plethora of smart home technologies, services and options contribute to increased complexity and growing energy demand	Smart Cup, Eli, Dabba
"*Aesthetic pleasures and gendered tech-work in the 21st-century smart home*." Strengers and Nicholls, 2018 [40]	The future smart home is envisioned to supplant convenience and permeated with pleasance with minimal effort	The smart home is generating new forms of household work and play. 'More work for father' pushes back on emancipation in household labor	Jack & June, Alfredo
"*Protection, productivity and pleasure in the smart home: Emerging expectations and gendered insights from Australian early adopters*." Strengers, Kennedy, Arcari, Nicholls, Gregg, 2019 [41]	Smart homes will contribute to improved protection, productivity and pleasure	Protective technologies can present 'stalker's heaven', smart home technologies reach only a selective group of tech enthusiastic men and create new forms of domestic labor	Jaimy, Rain

Based on earlier experiences with a workshop in a similar format [42], students are guided through a rough series of steps, which they iterate several times during the ten weeks of the course. After reading their Core Reading at least two times and discussing their views on it within their teams, students formulate research questions pertaining to future everyday life. They are then challenged to develop a Research Product [35] that allows them to study a specific aspect of this future. In their choice of focus, the student groups are encouraged to take concrete examples of practices,

artefacts or situations from their Core Reading, and to view their design not as a solution but as a materialisation of a certain 'what if …' question.

To work towards what Candy [43] refers to as diegetic integrity, meant to place people into the imagined future everyday ('Storyworld' for Candy) as seamlessly as possible, students are repeatedly probed to develop a scenario that 'holds together on its own terms: no gaps in logic, no clumsy flashing arrows' [43]. To support students in this effort, they are offered two workshops: one on Future Probing [44], a method to create future worlds using signals, and one on using improvisational role play that takes practices as a unit of design [45]. Through these workshops, they are facilitated to reflect on a wider range of methods to draw people into their scenarios by considering how to represent 'future contexts' and 'future people' in addition to the 'future artefacts' they produce. In these deployments, the Research Products are used as vehicles to collect data towards their research question: this can be auto-ethnographic, focus groups, role-play, questionnaires, longer-term field studies in people's homes, expert consultations, and so on. To stimulate high quality research products, the course includes a midterm critique in an exhibition style set-up in which the teams present their Research Products.

After the exhibition, the students deploy the Research Products to collect data to answer their research question, while, in line with speculative design practices [46] they are reminded that their design process also renders valuable insights towards this end. The final deliverables for the course are a paper (preferably in the form of a pictorial) written with the group, and an individual reflection of maximum 2 pages. In addition to being assessed by the course conveners, the pictorials were reviewed by some of the authors of the Core Readings.

3.1 Data and Analysis

The course has now run for four consecutive years. Because the COVID-19 pandemic in the third run made it difficult to make, critique and deploy physical Research Products, this edition is not included in our current analysis. The fourth run, also virtual, happened after data analysis for this paper was concluded.

The first two editions resulted in a total of 14 research products and accompanying pictorials. Additional materials include reflective notes by the course conveners, the course materials and the expert reviews on the 14 pictorials, and the formal, anonymous course evaluations. Both authors have been involved as teachers in the course. The first author was involved in setting up the course, and coordinating it for all four editions. During the course we practiced cross-coaching and held staff meetings to exchange experiences of coaching sessions and reflection on points where students struggled or exceeded expectations. The 2018 edition of the course was evaluated with a focus group led by the first author. Anonymous course evaluation forms were filled out by 56 % of the students in 2018 and 32% in 2019.

Ten projects were selected for analysis. Of the other four, two were not successful for reasons unrelated to the course set-up and two focused on professional instead of domestic settings. These two were not included in our data-set, which was originally compiled and coded in an earlier round of analysis, the scope of which was focused

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on how students questioned the 'smart home ideal' through their projects. We reflect on this limitation in the discussion.

Data analysis was done in several rounds, including intermediate presentations at conferences [42, 47] and workshops [48]. A draft of the paper was checked for consistency with their experiences by a former student that followed the course.

The final deliverables of the student groups[1] formed focused and concise forms of evidence for their learning. In the papers, they had to make explicit their interpretation of the Core Reading, explain the reasoning behind their Research Products and deployment set-up, and present and reflect upon their results, including generalizing towards applicability beyond the specific project. Throughout the paper, projects are referred to by the name the students gave to the central Research Product. We have analysed these papers with a focus on the different ways in which the students engaged with their Core Readings, and the types of knowledge contributions they presented following a grounded theory approach [49].

3.2 The Projects

Below we briefly introduce the ten student projects, describing their engagement with the Core Reading, their Research Product and main findings.

Aimy responded to the paper 'Screened Intimacies' [37]. Screened Intimacies uses the post-structural conceptual lenses of molarization [50] and dromology [51] to critically investigate social connection through technology, and applies these in an ethnographic study on the use of the dating-app Tinder. Screened Intimacies argues that the 'swipe logic' that is central to the Tinder user interface contains a directive script of speedy, binary decisions based on visual information that is reshaping practices of social connection and intimacy, which erode the 'time-distance required for meaningful human relations' [37] and contributing to the commodification of bodies.

Starting with the idea to exchange this interaction style from visual-based to audio-based, the students worked iteratively to develop an alternative dating app. This resulted in a high-fidelity, physical device and related app that was deployed with two participants. From this deployment, the students concluded that the audio-based dating interface showed potential to support more desirable forms of intimacy in dating.

[1] At the time of the first two editions of the course the regulations regarding project ownership preceded the new ethics procedures that were installed in the department and the new rules regarding idea ownership for students. In these former regulations all material generated within educational settings became ownership of the department. We were not able to reach all students to ask for permission to use their materials for this paper because most of them have since graduated. To protect their privacy but still acknowledge their contributions we choose to represent the projects anonymously and mention all student names in the acknowledgements. Individual student reflections were not included as data because they were considered too personal.

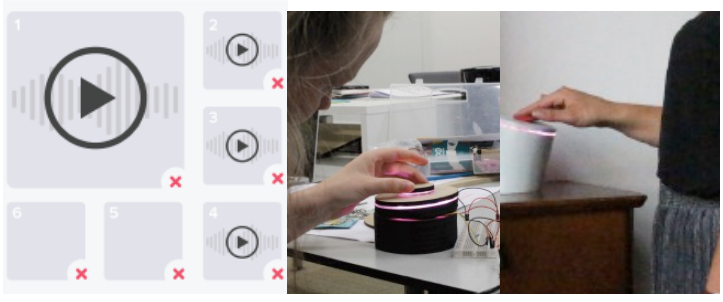

Figure 2. The iterative development of Aimy, including participatory design of audio profiles, interaction style, script, and type of voice.

Jaimy responded to Strengers et al. 2019 [50], who, referring to a wider body of work, argue that smart home technologies have a risk of contributing to the gender divide in society. Smart home technologies tend to be directed at, and attract, masculine users more than feminine users. This contributes to masculine members of the household controlling the settings of devices, and adds new forms of labor that withdraws them from more traditionally feminine chores.

Presenting a futuristic cooking practice in which precise measurements of high-tech ingredients and automation play a central role (Figure 3), the students took an opportunistic stance in the project by asking whether adding 'smart' features to traditionally feminine chores – in their case cooking – could reduce this gender divide. Based on their small-scale deployment, they argue that this can indeed be the case.

Figure 3. Jaimy: Future cooking device, and examples of its use.

Eli responds to Strengers and Nicholls [39], which critiques the often complicating effects of ambient automation, by proposing an alternative design approach that

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focuses on recursive rather than serving relations. They illustrate the proposed approach with an exemplar: Eli. Eli, developed through various iterations, is an interface controlling a connected light bulb that responds to the way in which the interface is caressed over time (Figure 4). Eli illustrates a design approach that moves away from the idea of ambient automation, towards an approach that *foregrounds* technology and brings it explicitly into everyday life through a friendship type of relation.

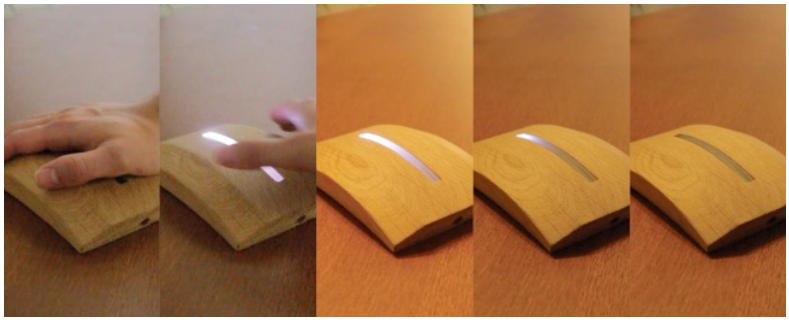

Figure 4. Eli's stages of interaction and feedback.

Dabba also worked from Strengers and Nicholls [39]. As with Eli, the students responded to the Core Reading's critique by imagining a different role for technology in future everyday life, i.e., as collaborator instead of servant.

Figure 5. The Dabba design.

Their research product, Dabba, or "the Dabba Experience", is an example of this approach for the case of cooking. Dabba is a connected device that assists in but doesn't take over the activity of cooking a meal by guiding the sequence and timing of adding herbs (see Figure 5). Different from the previous projects, these students find additional challenges with their proposed approach, for example the unwillingness of users to take care of their devices.

Laundry Buddy responds to Schwartz Cowan's classic critique on what she coined 'the industrial revolution in the home' [36]. Illustrated with a case study of changes in laundering practices in early 18th century North America, Schwartz Cowan argues that

this revolution has actually led to 'more work for mother'. One, because the spread of washing machines happened in parallel to a demise in domestic servants, and two, because their introduction was accompanied by rising standards of cleanliness and expanding wardrobes.

However, this idea of home automation technologies having effects that are opposite to what is generally expected – due to parallel changes or changing standards – did not feature in the considerations of the Laundry Buddy design or deployment. Rather, Laundry Buddy, a device and app that enable direct and continuous communication between washing machine and users (Figure 6), explored what could be the added value of such communication.

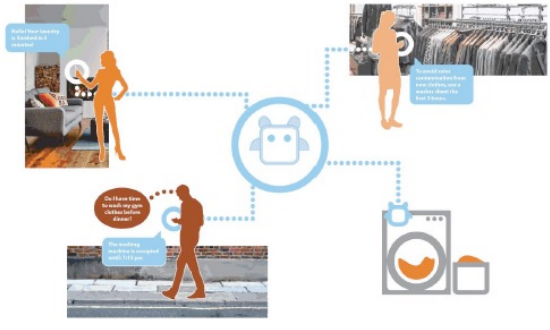

Figure 6. Laundry Buddy near-future scenario.

Alfredo responds to Strengers and Nicholls paper on Aesthetic pleasures and gendered tech in the 21st century smart home [40]. The project focuses on the Core Reading's critique of the 'full automation' pursuit of smart home industries. By raising the question: 'what will be left for people to do in case this ideal is realized'? the students extrapolate the idea of full automation into a fictional future. To explore the question, they created an extreme future scenario supported with audio fragments expressed by Alfredo: the smart home assistant that 'manages and forecasts all needs of the household', and a scale model home (Figure 7). The future scenario, set in 2050, includes an assumed further blending of private and public space, which was inspired by the Future Probing workshop and based on a trend analysis conducted by the students. For their deployment, they asked smart home specialists – professionals working on connected devices for the home context – to enact a day in the life.

In their data analysis, the students identify challenges with the level of control that the imagined inhabitants of the future home are anticipated to find acceptable – even with the 'ideal' smart home they create, as well as contradictory expectations. One participant for example imagines their character to 'have complete control of the data flow and the power of deciding what happens', which contradicts, or resists, the idea of full delegation behind the scenario.

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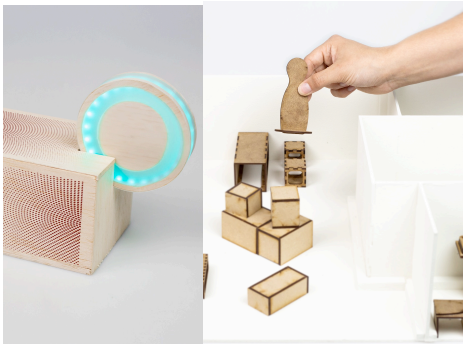

Alfredo Quote example:
"*To all the travellers: remember that today there is maintenance in the Hyperloop Tunnel direction Miami - Rome. Please, check www.hyperloop.com for alternative routes!*"

Figure 7. Alfredo and the scale model simulation with play-acting and script excerpt.

Mister Owl responds to Neven [38]; a study following the development of gerontechnological innovations that, while intended to support elderly to live at home longer, are argued to undermine their autonomy and the qualities of their house as a home. Building on the issue of autonomy loss, the research question addressed in this project was: 'What if monitoring systems did not simply measure when elderly are getting tired, but would also have the authority to decide when they have to go to bed, just like their parents used to do in their childhood?'.

Mister Owl, referring to a childhood figure exaggerates the problem framing of loss of autonomy by materializing the provocative proposition of people turning more child-like as they age. The deployment set-up was such that the students performed scenarios situating themselves and their parents 30 years into the future. Mister Owl, a Wizard of Oz device, would inconspicuously sit in the parent's living room until a certain time in the evening when it would start sending increasingly obtrusive signals that it was time to go to bed, up to the point of switching off all the lights (Figure 8).

Although some conditions apply, mainly of personal control over the technology, the students conclude that smart home technologies, even when somewhat paternalizing, are imagined to be acceptable by future elderly, and offer recommendations for assistive technology design that allow elderly to live at home longer.

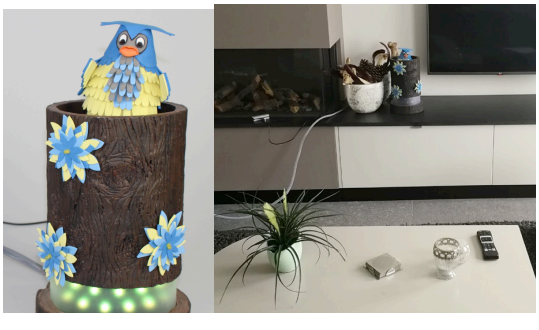

Figure 8. Mister Owl design and Mister Owl in context.

Jack & June, developed in response to 'Aesthetic pleasures and gendered tech-work in the 21st-century smart home' [40], explores perceptions of gendered technologies by making two high fidelity packaging prototypes of gendered smart home assistants (Figure 9).

The students asked themselves: 'If the smart home continues developing towards gender stereotypes, how might it clash with developments in society that try to move away from these stereotypes?'. Departing from the problem derived from the Core Reading that gendered technologies are problematic, the research product exaggerated the gender stereotypes of a caring housewife and protective 'man of the house' through a set of extreme behaviors. For their deployment, they selected millennials as representatives of a group with progressive attitudes towards gender stereotypes.

JACK	JUNE
- guards your home	- learns your food habits
- control over locks	- maintains fridge content
- locks the doors after 22:00	- locks fridge after 21:30
- maintains energy usage	- switches of tv after 22:00
- maintains temperature	- orders household products
- controls the lights	- maintains the house

Figure 9. Jack & June packaging and main characteristics.

Both smart home assistants were discussed by their nine participants as being infiltrating and restrictive – so they crossed the line of acceptance in terms of their imagined behavior. However, participants only noticed the stereotypes after being pointed out to them, and most of them did not have any objections against the use of such stereotypes. One even mentioned that they found their use convenient, as 'it can make life and decision-making easier'.

Rain responds to Strengers et al. [41]. Within the themes of 'protection, productivity and pleasure' discussed in the paper, these students focused on 'protection'. They did so by focusing on the identified risk of smart agents becoming 'toxic' to (female) occupants because they were used by their (mostly male) users/installers for monitoring without consent.

Rain (Figure 10) – including a high-fidelity home hub, visual style, unboxing experience, script and carefully selected sound scape – is a smart home assistant that is carefully designed to become increasingly intrusive over its week-long deployment. As the students explain, eventually, Rain even referred to 'our' house and for example called for a maintenance company for which the householders received a physical invoice addressed to Rain. Inspired by the idea of the 'creepy line' worked out by Pierce [52], the design was not made to please, but to 'elegantly horrify'.

The students' main finding was that the kind of decisions participants did not accept from Rain were related to something that was personal for them. However, the things that were indicated as personal differed per participant. For example, one participant found it unacceptable if Rain ordered clothes for them while for another it

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was fine. The subtle transition in the script from Rain speaking about ‘your’ home to referring to it as ‘ours’ evoked similar, dismissive reactions in all participants.

Script day 1: ‘I noticed a breach in your home safety. The window in the living room doesn’t seem to close properly’
Script day 6: ‘The food in our refrigerator has become a health hazard’, new food has been ordered and paid for.

Figure 10. Rain visual language, its packaging, and excerpts from script.

Smart Cup, developed in response to 'Convenience and energy consumption in the smart home of the future' [48], used a cup equipped with random light behavior (Figure 11) to explore people's expectations of smartness. The idea to focus on expectations of smartness came from the identification in the paper of smart technologies often not living up to their promises, i.e., ‘energy efficient’ technologies leading to more energy demand and household appliances leading to more housework. This made the students wonder: ‘What if this development continues and devices reach a point of complete dishonesty?’. They set out to explore how the ‘smart’ narrative, accompanied by a clearly ‘dumb’, dishonest artefact is capable of shaping people’s behavior and practices.

Figure 11. Smart Cup design and deployment.

In their small-scale deployment, the students asked their 5 participants to use 'Smart Cup' for several days, without explaining what Smart Cup actually did or was for. Their findings suggested that expectations of smartness can be quite powerful. Even though participants were aware that the cup could not in fact be 'smart'– several were even trained interaction designers, they still interpreted the random lights as an advice (to drink more water) that they were inclined to follow.

4 A Framework and Two Patterns

Through our analysis of the ten projects, we developed a framework that links the idea of design as an iterative conversation between problem and solution [53, 54] to the activity of exploring and shaping the alternative paradigms introduced in the Core Readings. The framework we constructed based on these results forms one of the contributions of the paper and helps to identify recommendations for teaching criticality in and through design. The framework is further explained below using examples from the projects to illustrate. In the next section we explain the two patterns in more detail, including variations on them in the projects.

4.1 Types of Knowledge Contributions

Within the projects, we identified three different types of knowledge contributions: (1) Alternative Solution Spaces, (2) Alternative Design Approaches, and (3) Extended Alternative Problem Spaces. In addition, two patterns emerged that link the original alternative problem space presented in the Core Readings to these knowledge contributions through two distinct critical design tendencies previously proposed in Pierce [55]: Oppositional and Accelerational (see Figure 12).

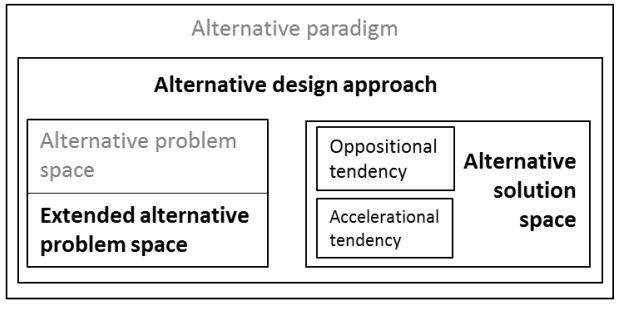

Figure 12. Types of knowledge contributions identified in the student projects (bold), and their foundations offered by the Core Reading (grey).

Alternative Solution Spaces. The first type of knowledge contributions made through the projects are the Research Products themselves. Through a material response to the alternative problem space, the Research Products embody and open-

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up an alternative solution space that can inspire additional concept developed in this space. For example, in response the Core Reading's critique on the illusion of ambient automation, Eli embodies the concept of an attention seeking friendship type of relation with IoT, and in response to their reading's problematization of IoT as tools in domestic abuse, Rain embodies the concept of an increasingly toxic smart home assistant.

Within this alternative solution space, Pierce's framework of frictional tendencies [55] helped us to identify two broad categories or tendencies of critical design embodied in the Research Products: Oppositional and Accelerational.

Oppositional Tendencies. Pierce describes the 'oppositional tendency' as 'exhibiting a critical stance toward current practices, technologies, situations, trends, values, etc.' [55]. The designs in this category exhibit this critical stance by representing a solution to the alternative problem. Projects in this category are Aimy, Jaimy, Eli and Dabba.

For example, Aimy, tries to 'fix' the limitations of Tinder by presenting an audio-based dating app, Jaimy aims to address the gender gap affirmation of smart technologies by developing an IoT solution for a traditionally feminine chore, and Eli and Dabba aim to address risks of 'smart home technologies' through alternative interaction paradigms of friendship, care and collaboration.

By materializing a solution for the alternative problem framing from the Core Reading, these Research Products inherently critique conventional design practices, technologies, etc. For example, by presenting the somewhat counterintuitive concept of an audio-based dating app, Aimy is inherently critical of the dominantly visual-based set of existing dating apps.

Accelerational Tendencies. The second cluster is situated around what Pierce refers to as an 'accelerational tendency', which is described as 'extrapolating the present beyond the boundaries of what is presently feasible, plausible or imaginable to the point of discomfort, outrage, confusion, or absurdity' [55]. In these projects, the Research Products materialize an exaggerated articulation of the alternative problem from the Core Reading. Other than the projects in the oppositional category, these Research Products do not aim to present a solution. Rather, as designs, they are deliberately made to invoke resistance and be unacceptable. Projects in this category were Alfredo, Mister Owl, Jack&June, Rain and Smart Cup.

Alfredo brings the idea of smart homes as taking over tasks to the extreme, fully pacifying inhabitants, Mister Owl is extremely paternalistic, Jack & June exaggerate gendered aspects of smart home assistants, Rain becomes increasing toxic, and Smart Cup is deliberately deceptive.

By materializing extrapolated or exaggerated aspects of the alternative problem framing into an (inverted) alternative solution space, the artefacts become vehicles to make the alternative problem framing accessible in new contexts.

Alternative Design Approaches and Extended Alternative Problem Spaces. While the requirement to make a Research Product steered students towards development of the alternative solution space, the course stimulated them to use the Research Product as a means for further knowledge development. Most projects generated such

knowledge, within which we identified two main forms: alternative design approaches and extended alternative problem spaces.

Alternative design approaches form responses to the alternative problem framing that have implications for how design is performed - i.e., in the form of guidelines, principles or instructions of what designers should do differently – that goes beyond the specific project. For example, Eli promotes and illustrates a design approach that foregrounds rich interaction and friendship-like relationships that develop over time, and Jaimy proposes an approach to achieving gender equality through design by integrating IoT into feminine chores.

Finally, several projects developed the alternative paradigm by extending the problem spaces described in their Core Readings. These contributions do not focus on what designers should do, but highlight additional challenges related to the role of technology in the realm of everyday life. For example, Smart Cup identifies a risk of the high, but unfounded trust that users have in smart technologies that wasn't part of the problem space presented in their Core Reading – the alternative problem space is extended through the design engagement.

4.2 Two Patterns

In addition to these three types of contributions, we identified two main patterns that link Research Products with the contributions (visualised in Figure 13). In Pattern 1, Research Products with an Oppositional tendency form illustrations of, and means to evaluate Alternative Design Approaches. In the second pattern, the Research Products followed an Accelerational tendency and through encounters with (future) everyday contexts, function as a vehicles to Extend the Alternative Problem Space. For each of these patterns, variations occurred in the data. The patterns are elaborated below with a focus on their variations as points of insight to further enhance student learning.

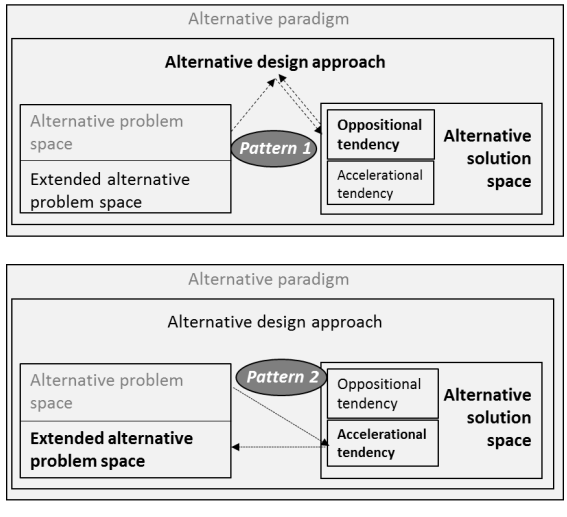

Figure 13. The two main patterns of using Research Products to explore the design space implied by the alternative paradigm presented in the Core Readings.

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Pattern 1: Alternative Design Approaches and Oppositional Tendencies. The first pattern is followed by the projects Aimy, Jaimy, Eli and Dabba. Aimy deviates from the pattern because the project doesn't generalize towards a design approach. Eli shifts back to conventional paradigm and Dabba deviates because it is the only project that uses the Research Product both as an illustration and validation of an alternative design approach, and for extended alternative problem framing.

While arguably successful as a critical, oppositional design in the sense that Aimy forms a materialized, well-founded critique of Tinder and visual-based dating apps more generally, the exploration of the alternative paradigm does not extend beyond the alternative solution space.

Jaimy, Eli and Dabba all use the oppositional design as a vehicle to illustrate and evaluate an alternative design approach. Like Aimy, Jaimy responds to the Core Reading's critique on technology by designing something that 'solves' the issues highlighted. Other than Aimy however, Jaimy represents an example of a potentially larger category of technologies, i.e., masculine technologies designed for traditionally feminine chores. The alternative paradigm and problem space from the Core Reading – smart technologies mainly attract masculine users, withdrawing them from feminine chores – is engaged with creatively through the design, representing an alternative solution space for interaction design.

Dabba and Eli similarly develop and evaluate claims about how designers should design the broader category of smart home technologies, respectively through fostering collaborative and friendship relations. However, what we identified in Eli is that key aspects of the alternative paradigm from the Core Reading are circumvented. In this case by shifting responsibility for undesirable effects of technologies from designers to users. Eli forms an example of the alternative relation between user and smart home that is, in the words of the students, intended to 'disrupt the convenience narrative' critiqued in their Core Reading. They then move on to argue that this take on the alternative solution space redefines the alternative problem space introduced in their Core Reading, claiming that: 'it can be argued that the core of the problem sketched by Strengers and Nicholls [39] lies within the usage of smart devices by people, rather than the usage of power by smart devices'. This is an interesting move that is in line with the iterative development of problem and solution spaces. However, what happens here is that the students circumvent the Core Reading's critique on the role of technology design in perpetuating a deceptive and resource intensive 'convenience narrative' by shifting the problem from designers to users. As such, they don't question the paradox of creating convenience with a growing number of connected, power consuming devices meant to 'disappear in the background'. Rather, they design another interaction style meant to invoke a more conscious and conscientious attitude towards technologies in users. In other words, this move seems to take them back to a more conventional type of problem framing that doesn't require fundamental reconsideration of their own practices.

Another opportunity for further learning that we identified in Pattern 1 is that the students find it difficult to be critical of the potential risks and unintended effects of their designs. Aimy, for example, is as much an intervention in intimacy as Tinder is, but unintended and potentially undesirable secondary effects are not critically evaluated in the deployment. The Core Reading did offer handles for a more critical evaluation by offering theoretical lenses, and illustrating how Tinder is creatively

circumvented in use. Similarly, in her review of the pictorial of Jaimy, Strengers rightly points out that while it offers a novel perspective, it is still enforcing gender stereotypes.

This tendency to emphasize positive effects of the design may partly be explained by the fact that the oppositional designs are positioned as solutions, and the result of many careful iterations. It seems that the extensive time investment for developing Aimy into a credible alternative to Tinder, and Eli as an attractive alternative interaction paradigm may have contributed to the student's tendency to evaluate them in a manner that favored findings evidencing success.

Dabba was an exception here. In analyzing the encounter of their design with 'users', these students take a critical stance that shows signs of what Bardzell and Bardzell [22] refer to as skepticism, i.e., taking into account that their participants might be 'fooled by the system' of an ideal of home automation. For example, their Research Product helps them identify that instead of viewing all household chores as problems to be solved by technologies, what is considered pleasant or cumbersome household labor differs per person and situation. This problem framing that emerged from the deployment steps away from the 'ideal' of full automation and highlights that there can be pleasance in doing household chores.

Similarly, the Dabba group identifies a challenge of the shift towards their proposed paradigm of human-technology collaboration in the form of unrealistic expectations of future technologies among their study participants. And, related to this, a low willingness in people to do something for the technology, such as refill or clean it.

Finally, they reflect on the unwarranted trust participants showed in the device's authority. Participants would talk about Dabba as directing their behavior, e.g., stating that when Dabba starts beeping "you have to start cooking", and believing the measures of ingredients provided by Dabba over the measures given in the recipe. Different from the previous three projects, these students reflect critically on the role of their design in everyday life and find contradictions in what their participants say 'between the lines', thus critically questioning their own 'solution'. By doing so, they extend the alternative problem space from their Core Reading through design.

Pattern 2: Accelerational Designs and Extended Alternative Problem Spaces. The projects in Pattern 2 show a different approach to exploring the alternative paradigm and design space introduced in the Core Readings. This pattern occurs in six projects, each with slight variations. Roughly, these projects follow the pattern of developing a Research Product that materializes extrapolated or exaggerated aspects from the alternative problem spaces. Rather than being evaluated for their feasibility, they are used as vehicles to extend or further explore the alternative problem spaces introduced in the Core Readings. Our analysis shows that while this approach can add unique new knowledge to which traditional STS methods do not have access, it is difficult for the students to remain within the alternative paradigm. Eventually, only Smart Cup fully follows the Pattern 2 ideal, while two other projects, Jack & June and Rain, closely approximate it.

Smart Cup materializes an extended version of the problem space identified in the paper, i.e. technologies can be deceptive, leading to effects that are opposite to their promises. Through their deployment, the students then identify yet additional

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problems within the alternative paradigm, namely the power exerted by making, or claiming to make objects 'smart'.

Jack & June forms an accelerational provocation that exaggerates the alternative problem framing of gendered technologies identified in the Core Reading. The deployment does not lead to the anticipated extension of the alternative problem space. While the students had expected to learn more about potential, undesirable effects of gendered technologies on everyday life through the reflections of their participants, this did not work out. In spite of the strong gender stereotypes, their participants did not recognize the problem. As such, the design did help the students identify additional, complex challenges around gendered technologies.

Rain also extended an alternative problem space, but not the one argued in the Core Reading. Rain was used to explore the point at which a protective smart home agent becomes toxic. This focus is related to but circumventing the point of the paper that smart home technologies facilitate toxic masculinity. Interestingly, the students drifted towards Pierce's concept of 'the creepy line' [52]. This concept sits within a broader context of problematizing the proliferation of smart home technologies and can therefore be argued to represent an alternative paradigm. Through the deployment of their Research Product, the students identified a 'creepy line', which was crossed when Rain started to position itself as a member of 'our' household. While this finding doesn't directly engage with the problem space identified in the Core Reading of seemingly innocent smart home technologies being used as tools in domestic abuse, it does render insights that extend an alternative problem space through an accelerational design.

This does not mean that the other three projects in this pattern failed. A recurring variation on this 'ideal' pattern was the use of accelerational designs to extend a conventional problem framing and solution space. Laundry Buddy, as mentioned previously, follows the pattern of acceleration and extended problem framing within a conventional paradigm of continued home automation and spreading of IoT in everyday life. Alfredo is somewhat more ambiguous in the sense that it forms an idealized, yet slightly over the top home automation scenario. By extrapolating and materializing the idea of 'full automation' problematized in the Core Reading, Alfredo poses a fundamental, critical question about the role of people in these fully automated futures: what will residents do if domestic life is fully automated? In their data analysis, some irony is identified, particularly between anticipated delegation and desired control, but the project is mainly about opportunity finding for new technologies to offer more pleasance. Therefore, Alfredo can be viewed as an exercise of extended problem finding within a conventional paradigm of technological progress and increased delegation of domestic chores to technologies.

Finally, while Mister Owl, with its explicitly childish design and over the top intervention of switching off the living room lights at bedtime is not designed to form a solution, it did not function as a vehicle to extend the alternative problem space. Insights derived from the deployment are translated to recommendations for assistive technology design that assumes the 'general good' of designing technologies that allow elderly to live at home longer critiqued in the Core Reading.

5 Discussion

In our discussion we relate our reflections on the ten projects back to the three elements we integrated into the course set-up and related work.

5.1 Drawing on STS literature

As illustrated above, the Core Readings from STS worked as foundations for critical designs, but this construction also has limitations. While the STS papers offer alternative paradigms for relations between technological innovations and societal change, their view on state-of-the-art design approaches is, understandably, not fully up to date. As such, the focus that students were guided to take on their Core Reading created a blind spot for state-of-the-art design theory.

For example, while Dabba and Eli stay within the alternative paradigm as framed in the Core Reading, the alternative design approaches they propose show similarities to approaches focusing on Human-Computer Collaboration [56] and Slow Technology [57] that have been around for a while in design and HCI literature.

Comparing this set of projects with published work in design research highlights a potentially productive difference. In Odom et al. [58] for example, considerations behind developing PhotoBox according to the principles of Slow Design are reported and reflected on in detail. Focusing more on the design processes of the Research Products that proposed, illustrated and evaluated alternative design approaches might add to the actionability of the outcomes of Pattern 1, and therefore the potential of integrating them into the students' professional design practices.

Having said this, we also see signs of original contributions that can be traced back to the STS readings. Compared to projects from design literature that also use a design to explore and illustrate alternative design approaches, such as the Photobox [58], Table-non-Table [59] and Morse Things [60] exploring implications of a phenomenological design paradigm, or the Indoor Weather Station [61] exploring implications of Ludic Design – the projects in this course integrate a societal critique that extends beyond the level of human-product relations, towards the roles that technologies play in societal issues such as gender, power disparities, and energy demand. In the words of Ward [1], STS literature might offer a basis for a more 'structural' form of critique on the role of design in society. More in-depth literature engagement in this area would be needed to substantiate this point, but generally, work in human-computer collaboration is not positioned as a critique on the convenience narrative, or the role of servitude in which smart home technologies are positioned, and Slow Design does not make the link to domestic energy demand.

However, in spite of a range of successes, a returning issue with the projects is their relatively superficial engagement with the alternative paradigm, which, in several cases brought them back to a conventional paradigm during the project. Considering the challenges of making a paradigm shift, this is only understandable; students are likely to resist implications that undermine their chosen professional practice, particularly when these conventional paradigms are also carried by their 'users'.

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5.2 Critical design and paralyzing problems

The designs in the Accelerational pattern were deliberately not meant as solutions; rather, they were meant to highlight the problem space in the Core Reading by exaggerating it – as such they became unattractive or even deliberately unacceptable as solutions. This Accelerational tendency can be recognized in many critical and speculative design projects from literature. Examples are HappyLife [62], extending technology's abilities to read emotions, IKEA Catalogue [63] and the artefact series Polly, AllSpark and Orbit Privacy [64], both extrapolating expectations of IoT proliferation in everyday life, and GiggBliss [65], extending developments towards automated distributed energy systems. Compared to these examples, however, the type of critique embodied in the Research Products building on STS literature highlights alternative problems that link to societal issues that lie beyond expected technological developments, such as gender, autonomy and social connections.

Moreover, stimulated by the 'Material Speculation' element and focus on future everyday life, the students didn't stop at the artefacts. Similar to GigBliss [65], they used their Research Products to extend an alternative (or conventional) problem space, presenting a stepping stone towards a different set of 'solutions'. Our idea with this set-up was that this generalization element could add to the uptake of the alternative paradigm into the developing design practices of the students. What is interesting, as well as contradictory, is that these extended problem spaces weren't necessarily actionable for design. Dabba, Smart Cup and Jack & June highlighted complex extended alternative problem spaces that further problematized the role of technology, and their designers, in societal crises. For example, results indicating that people are reluctant to take care of their 'smart' technologies, that 'smartness' has unexpected power over people's behavior, and that the problem of gender stereotyping may not solve itself through ongoing changes in gender perceptions.

While further analysis is needed here, these outcomes may still have the paralyzing effect on students that the course was trying to avoid. A future direction in this teaching may lie in building on such outcomes to think about alternative roles for designers in society, for example in 'undesigning' technology [66], or designing for maintenance and repair [67]. In terms of our patterns, this would mean making an additional step from the extended alternative problem space to alternative design approaches through Oppositional designs.

5.3 Critical design and STS contributions

Having said this, the STS scholars that were asked to review the pictorials indicated that these projects offered contributions to knowledge that were unique for a designerly approach. While not directly actionable for design, the projects added to the problem framing in the Core Readings in a way that traditional STS research could not. In other words, the Research Products help to gain access to a realm of knowledge that is not accessible with traditional social science methods. What we see with these projects is students able to grasp the meaning of the critique, and extend its logic through their designs. This results in a research product that's more equipped to articulate the critique than the original design being critiqued, because the latter has

already been normalized in society. This observation led us to reflect that possibly a collaboration with social science students could be fruitful here, potentially leading to mutual benefit.

This link brings in another aspect from STS teaching pedagogy. While in the course students focus on one Core Reading, Gravey et al. [68] foreground the importance of teaching students a range of perspectives. For example, in their teaching approach Theoretical Theatre, they focus on understanding differences between up to four competing social theories. Theoretical Theatre uses semi-improvised comedy performances in which teachers, and in some cases also students 'portray different characters who physically embody theories in interactive scenarios'. These characters 'may get along or argue with each other, reflecting academic and policy debates between different perspectives' [68]. Such a creative way of engaging with various alternative perspectives might also work by materializing them into Research Products. This could nuance the students' understanding of different paradigms.

Something we also couldn't include in this paper is a further reflection on Pierce's [55] frictional tendencies. We identified two in our analysis, but what about the other three? Why weren't they as present in this set of projects? What patterns of knowledge development and learning might be effects of steering students towards them? Further work on analysing the projects currently not included in this paper could shed light on these questions.

6 Conclusions

In the course Researching the Future Everyday we set out to teach interaction design students 21st century skills of critical thinking, and specifically, to equip them with the skill to continuously question and adapt their own practices. By offering an overview of the main elements and structure of the Researching the Future Everyday course along with a set of illustrated outcomes, we hope to have offered an approach that other teachers in interaction design may apply.

To complement this set-up, our analysis highlights a number of recommendations. One conclusion that can be drawn from our reflections is that oppositional designs seem to lend themselves better for the development of alternative design approaches, while accelerational type designs seem more suitable to generate knowledge contributions that are critical of design itself and generate new questions. More design-oriented students might therefore find more satisfaction in an oppositional type of approach, while more research oriented students might be more at home with an accelerational one. Below we offer some additional concluding recommendations for each of the two tendencies:

For oppositional tendencies (Pattern 1):

- Stimulate the students to take a distance from their carefully designed 'alternative solution' when deploying it, drawing on critical theoretical perspective offered in their Core Reading to identify limitations, e.g. Aimy disrupts intimacy, Jaimy is binary;

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- Stimulate the students to adopt a skeptical disposition towards the responses of their participants – these participants are likely to be carriers of the conventional, dominant paradigm, which isn't necessarily shifted with a provocative design;
- Stimulate the students in this pattern to carefully document their design process (e.g. by showing Photobox or similar work as an example), because the alternative design approach they develop is their main knowledge contribution.
- While being careful not to overwhelm them, make the students aware of similar work from design and HCI literature. Engagement with state-of-the-art design theory however isn't essential for their learning in this case – the priority is that they develop alternative design approaches in response to critical theory.

For accelerational tendencies (Pattern 2):

- Prepare students that the outcomes of this type of project is more likely to raise new challenges and questions than actionable, novel pathways for design;
- When students are reverting back to a conventional problem space, make them aware of their shift, discuss why it might be happening and try to jointly identify findings that extend the alternative problem space;
- When possible, stimulate the students to perform an extra, quick iteration that works from their extended problem space towards an oppositional design, i.e. one that addresses the extended problem identified through the accelerational design;
- Facilitate collaboration with STS students/scholars to let the students experience the unique value of designerly research in generating STS knowledge.

To close, we've experienced that offering students one Core Reading to focus on helps to guide them through a design research iteration – formulating a research question, making a design and deployment set-up, collecting data, analysing data and writing a paper – within the time-span of 10 weeks. However, to facilitate continuous and repeated critical adaptation, more emphasis could be placed on STS as a resource for alternative paradigms that can offer a potential way out of the increasingly problematic role of interaction design in global crises. One way to do this would be to pay more attention to introducing students to the field of STS beyond one reading, to facilitate collaboration with students or scholar from STS, and bringing explicit comparison of different critical theories into the course.

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