Imagining Responsible and Just Smart Home Technologies: Troubling Sociotechnical Systems Through Co-Design

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Abstract

Smart home technologies (SHTs) are prominently featured in energy transition plans due to their potential to mitigate climate change effects. The representation of SHTs and their associated imaginaires significantly shapes perceptions and technology development. However, mass adoption of these technologies risks deepening social inequalities, enabling pervasive surveillance, and worsening environmental impacts. Previous studies involving users to foresee undesirable technology impacts fail to challenge industry solutionism effectively. This thesis reports on a co-design process organised to trouble dominant unfair sociotechnical systems behind SHTs, aiming to foster a more responsible and just imaginaire for the technology.

Working with 22 co-designers grouped as professionals, early adopters, and late adopters of SHTs, the study included five exploratory and speculative design workshops, an online focus group, and 14 evaluative interviews, analysed through qualitative coding and visual analysis. The co-design process uncovered three key insights: (i) prevalent techno-positivism exists in the imaginaires across different adopter groups and expert circles; (ii) issues with SHTs are systemic, impacting devices and usability, production and consumption, and the broader relationship between people and technology; (iii) when enacted through a democratic participation infrastructure focusing on mutual learning, co-design can disrupt unequal power dynamics, leading to more responsible and equitable outcomes associated with SHTs.

Co-design can enhance distinct social groups' abilities to critically represent alternative imaginaires. Viewing participants as partners rather than research subjects fosters a different relationship between industry and users, challenging dominant sociotechnical systems. This thesis presents three contributions: (a) conceptual framing SHT through its troubles instead of promised solutions; (b) maintaining engagement with SHT troubles via a non-solutionist co-design methodology; and (c) evidencing participants' journeys of critical consciousness in co-designed speculative artefacts. Without challenging broader systemic and power dynamics, participatory practices like co-design risk perpetuating the same injustices produced by mainstream design.

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1. Introduction: It's a Smart World, After All

Information and Communication Technologies (ICTs) have entered many aspects of everyday life. Their widespread presence has been reshaping civic, economic, and political practices since the popularisation of personal computers and the Internet. With a heterogeneous distribution of access and skills, individuals around the world now have unprecedented contact with electronic devices. Moreover, these devices have shared a common denominator in the past decade: smart.

Smartphones, smart TVs, smart speakers, and smartwatches promise to be cleverer than their regular previous variants. In the context of computer-human interaction, a "smart" electronic device is one that responds to the user's input with an apparent intelligent behaviour. Even if the use of the prefix "smart" nods to advances in science and technology like Artificial Intelligence (AI), some smart technologies have only a simple relay and feedback system—i.e., smart technology does not necessarily deliver a technically more advanced device but instead encapsulates an ideal connected to theories of machine reasoning.

Unsurprisingly, the influence of smart technologies has reached everyday household life. Electronic devices and digital appliances have been framing domestic life in innovation waves from the electrification of the home, with fridges and vacuum cleaners, to the adoption of embedded computing in home technology, with thermostats and TVs. Modern automation plans debuted in the early to mid-20th century after enslaved and servant domestic work was (mostly) replaced by the use of electric appliances (Aldrich, 2003; Woods, 2021). Socially expected to perform unpaid household work, women were then promised liberating devices with electronic and digital advances.

More recently, AI-powered devices seem to be bringing householders closer to the modern ideals of future living. Together, such devices form an automation "melting pot" encompassing assisted living, entertainment and comfort technologies, security systems,

and devices managing household resources and waste (Nyborg and Røpke, 2011). The latter group of smart home technologies (SHTs) managing household resources like energy, water, and waste has gained prominence due to their association with high-tech solutions to a complex global problem: the climate emergency.

Official reports from the Intergovernmental Panel for Climate Change (IPCC), an influential source of information on climate change from the United Nations, have presented the use of smart technologies as mitigating actions to make human settlements more resilient in the face of extreme weather events (Edenhofer et al., 2011; Intergovernmental Panel on Climate Change, 2023, 2015, 2007). SHTs' potential is associated with the need for an energy transition from carbon fossil to renewable sources. In such a scenario, for instance, a home's smart management system can autonomously cope with sudden availability variations in energy supply, and smart batteries in the house can efficiently store household-produced energy in case of power cuts. The overall expectation is that SHTs can play a key role in reducing carbon emissions associated with the household.

Such critical applications of smart technologies can be envisioned for industrialised contexts because of a favourable landscape of developments in computer science theories and a consolidated consumer electronics market. The digital data surge in the 21st century has been crucial for developing AI models such as Machine Learning (ML) and neural networks. SHTs use this processing power to improve action performance and responsiveness. Generative AI (GenAI) frameworks demonstrate unmatched capabilities in, for instance, accurately inferring a household's needs and resource management (Mongaillard et al., 2025).

In terms of hardware, the industry's manufacturing sophistication has enabled the addition of computing capabilities even to light bulbs. The popularity of SHTs can also be reflected in numbers: the North American Consumer Electronics Show (CES) has reported that representatives from smart home industries have ranked among the top ten attendance profiles by technology category, peaking at 31,009 representatives in 2020—almost double the number of representatives from gaming industries in the same year (Consumer Technology Association, 2024). In 2023, around 107 million smart speakers were shipped globally, and this figure is expected to reach 132.9 million units by 2026 (Statista, 2023). Moreover, the percentage of the worldwide population using SHTs in 2025 is estimated to be 77.6%, with a projected market revenue of US$174.0 billion. However, household penetration is expected to climb to 92.5% by 2029, with increased revenue projected at US$250.6 billion (Statista, 2025).

While industries consolidate SHTs' presence in the consumer electronics market, industrialised countries started energy transition plans to distribute smart energy meters and pilot low-carbon communities using smart technology (Ballo, 2015; Bugden and Stedman, 2019; Hargreaves et al., 2013). Nevertheless, undesirable consequences of the widespread use of smart technology have also been reported, undermining the positive contributions the technology can have for society and the environment. From increasing

the digital divide through generational and financial gaps to increasing a sense of fear through constant surveillance, the risks and harms of SHT can even jeopardise their contribution to mitigating the effects of climate change (Li et al., 2021).

Smart home technologies can deepen existing social inequalities. The distribution of access and skills to digital technology is not homogeneous, and with SHTs, social, economic, and educational disparities can worsen as the digital divide affects essential domestic routines related to energy and resources. Additionally, AI- and ML-powered smart devices risk being poorly trained by narrow clusters of data, which biases devices' responses to everyday inquiries. For instance, SHTs have been associated with the reproduction of racism in biased smart voice assistants better comprehending white users (Quaglia, 2020), and with sexism with female-gendered smart speakers, reinforcing problematic gender dynamics in the home (Baraniuk, 2022; Strengers and Kennedy, 2020).

Another undesirable outcome emerging from SHTs relates to privacy and security. Cases of smart cameras and sensors being hacked are no longer uncommon, with householders being victims of emotional and physical harassment augmented by their smart homes (Paul, 2020). Besides users' widespread worries over who gets to control the data captured by their SHTs (Dereymaeker et al., 2024), the privacy concern goes further as domestic abusers are taking advantage of relatives or ex-partners' lack of knowledge over the installed smart systems to monitor and control their routines (Lopez-Neira et al., 2019).

The most recent risk to receive attention from research and media reports is directly connected to the promising role SHTs can play in energy transition and climate mitigation plans. The opaque environmental costs of smart technology do not stop at the illegal mining of rare earths for electronic devices fabrication (Willenbacher, 2022). Previous research has demonstrated unanticipated social practices emerging from using smart meters—for instance, a rebound effect in energy use, as residents are constantly informed by price rates and availability, changing their routines to use more energy and spending less money (Gurzu, 2017; Morley et al., 2016). Yet, SHTs' most silent environmental impact is associated with the use of AI in devices. The data centres where AI and ML models are processed are resource-intense technology assets, requiring uninterrupted energy supply and purified water for cooling (Berreby, 2024; Dodge et al., 2022).

The current design of SHTs has been following the industry's technical possibilities instead of residents' needs and concerns. A quote usually attributed to Steve Jobs, Apple's co-founder, can demonstrate industry confidence in their products: "People don't know what they want until you show it to them" (Hansen, 2013). Without considering the foresight mysticism that such a statement can produce around technological development, this quote defines the forms of technology push that have been the key driving force of innovation, without regard for the diverse perspectives and everyday lives it could impact (Aldrich, 2003; Edwards and Grinter, 2001). Another element contributing to

the techno-positivist discourse presented by the digital technology industry since the late 1990s is what Evgeny Morozov calls "solutionism" (Morozov, 2013)—or the trust that any problem can be solved with technological products and services. However, when coupled with technological push, solutionism is responsible for poorly framed questions with answers in the form of devices that consumers might have never asked for—which can be associated with undesirable outcomes, deepening social inequalities, spreading pervasive surveillance, and increasing technology's environmental costs.

As smart technologies, specifically smart homes, seem to be at the core of future visions from governments and international organisations, there is a need to make the industry more responsible in anticipating risks and more just in distributing smart technology's social, economic, and environmental benefits. In this thesis, I suggest that bringing about such transformations requires, and arguably demands, changes to the design processes at the heart of contemporary SHT development.

1.1. Towards More Responsible and Just SHTs

Historically, policymakers have tended to govern and regulate technology development outcomes—i.e., after undesirable impacts have already affected society, the economy, or the environment (Stahl and Coeckelbergh, 2016). However, this is a form of retroactive governance of results that has begun to change in recent decades. Research and industry have been exploring strategies to anticipate and respond to technology's impacts before they happen, promoting more responsibility among research and innovation. One of the strategies is Responsible Research and Innovation (RRI), which intends to encourage more responsibility among practitioners from within the process through the inclusion of the external public (Owen et al., 2013; Stahl and Coeckelbergh, 2016). RRI frameworks promote deliberation to anticipate and respond to impacts before they cause harm. In addition to inclusion, anticipation, and responsiveness, the framework intends to bring more reflection to research and innovation.

Early critics of RRI highlighted the lack of political discussion regarding the framework's power dynamics (van Oudheusden, 2014). Even if RRI can avoid undesirable outcomes, it does not mean that fairer access to the benefits and burdens associated with innovation will be established. The RRI framework, however, has been adopted by important research and innovation funding bodies like UKRI (United Kingdom Research and Innovation Council), with the objective of bringing more responsibility and transparency to scientific research and industry (UKRI, 2023).

The inclusion of external publics who have not historically been included in scientific or industry research, nor in design processes, is at the core of RRI frameworks. Inclusion in technology design is not new and can be seen through experiments across different territories and periods. From the Scandinavian participatory design during the informatisation of local industries to the North American user-centred design improving

personal computing usability, methods for the participation of external actors in the design of new technology have endured to contemporary times where they co-exist and inform each other (Sanders and Stappers, 2008). Even with a constant interplay between participatory and user-centred design, the distinctive characteristics of each method are fundamental to position them in relation to how responsible and just they are. A third form of inclusion in design emerges from this scenario, with more opportunities to discuss power distribution within the technology design process. This is co-design.

Previous research on smart home technologies has indicated the use of co-design as an inclusion strategy to better account for user needs in the process of designing SHTs (Chidziwisano and Jalakasi, 2023; Ghajargar et al., 2017; Kozubaev et al., 2019; Raju et al., 2021; Renström, 2019). Such studies have justified the inclusion of users in the apparent gap between computer science and social science. This divide has been associated with the irresponsible outcomes emerging from the popularisation of SHTs, assuming that a better understanding of users' needs and expectations (coming from applied social sciences) would better inform technology development by industry (using computer science methods). However, most SHT co-design studies still lack a diverse representation of ideas and perspectives in their inclusion strategies, rendering participants as research subjects studied with the intention to improve smart devices—which, undoubtedly, reinforces the industry's solutionism (De Ruyck et al., 2019; Ngankam et al., 2023; Pradhan et al., 2020; Reisinger et al., 2023; Yao et al., 2019b, 2019a). Furthermore, participants as informants only reinforce an uneven power distribution between users and industry, which is part of the criticism of the absence of political discussion in RRI frameworks (Albertson et al., 2021; Koch, 2020; Levidow and Papaioannou, 2018; Owen et al., 2021; van Oudheusden and Shelley-Egan, 2021).

There is a need for research on SHTs to explore more diverse and reflective inclusion methods in the design and development of smart technologies. The underexplored potential of co-design is in enabling people to challenge dominant sociotechnical discourses. Instead of making a solutionist move and simply co-designing new smart technological solutions that appear more responsible and just on the surface, in this thesis, I propose repositioning co-design as a trouble-making method that has the potential to disrupt established regimes in favour of a more diverse and fair future with SHTs.

1.2. Troubling Sociotechnical Systems Through Co-Design

The social values invested in a design process are embedded in the created technology, making their way back to society once individuals start using devices—as technology objects afford some social practices but not others (Cruz, 2017; Feenberg, 2002; Winner, 2020). For instance, gendered smart voice assistants like Alexa seem to have been informed by a sexist social discourse that users would be more comfortable with a female

voice servant. Thus, with most current smart voice assistants presenting a female voice by default, problematic gender dynamics are not being challenged but reinforced (Strengers and Kennedy, 2020). The next time a designer needs to imagine a smart assistant, it will likely have a female name and voice.

The narratives and images of SHTs that an individual had previous contact with wield a formative role in the constitution of this individual's opinions and expectations over smart technologies. The French concept of *imaginaire* (Wunenburger, 2020) is useful here to describe the subjective and ontological processes of giving meaning to things and ideas. An *imaginaire* is constituted from the set of visual and linguistic expressions an individual has experienced. Thus, designers and developers draw on their *imaginaire* to create SHTs, while householders refer to theirs to interact with and use such technologies.

The industry's techno-positivist discourses behind current smart technology have reinforced a solutionist *imaginaire*, producing a sociotechnical system that benefits already dominant social groups (Mittelstadt et al., 2016; Verschraegen and Vandermoere, 2017). Alternative narratives for designing smart technologies need to be developed and nourished in favour of a more responsible and just sociotechnical system. Considering co-design's potential to discuss power dynamics and the role of inclusion in responsible innovation, this research aims to establish an interventionist approach to designing SHTs.

This thesis has three novel starting points connected to the constructivist understanding that if smart technology is socially constructed, it can be reconstructed. The first conceptual starting point repositions the focus of SHT studies from solutions to the tensions, contrasts, and oppositions surrounding the technologies. Instead of risking worsening existing problems or creating new ones, the scholar Donna Haraway (Haraway, 2016) calls for 'staying with' the complex troubles faced by contemporary society. For this research, instead of creating new smart technologies that could aggravate existing social, political, and environmental issues, I suggest that troubles can be used to raise awareness and provoke the necessary change in how SHTs are being developed and used. This can be enacted through a collective design practice.

The second starting point regards co-design's potential as a non-exploitative and democratic strategy for including people originally outside technology design. This methodological basis incorporates design theories describing designers' work or the "designerly" ways designers think, know, and act (Cross, 1982) as speculative, visual, and constructive—essential characteristics for coping with the troubles of SHTs. Rather than limiting its application to improving technological products, co-design can empower participants to challenge the dominant unfair sociotechnical systems through learning.

The thesis' third original starting point is empirical and is based on the lack of diversity in previous SHT co-design studies. The fact that smart technology has been mainly produced by the industry's technological push and not consumer demand exacerbates

the gap between computer science and social science. There is a need to diversify the inclusion strategies in co-design, allowing previously opposing stakeholders to meet and negotiate. Contact between diverse *imaginaires* can promote the necessary empathy for collective change in sociotechnical systems.

To the best of my knowledge, this is the first time that the designerly ways of co-design practice have been used to trouble dominant SHT *imaginaires*. In doing so, this thesis addresses three main research questions:

> *1. What are the dominant imaginaires shaping the development and use of smart home technologies?*
>
> *2. How do co-design methods affect the imaginaires behind smart home technologies?*
>
> *3. What are the implications of co-design for creating more responsible and just smart home technologies?*

Making use of methods drawn from art and design, this co-design research has been organised over four phases, comprising data collection and analysis. The 22 participants (or co-designers) in this research possess diverse levels of experience with SHTs and were grouped as professionals, early adopters and late/non-adopters of the technologies. Data collection comprised five exploratory and speculative design workshops, an online focus group, and 14 subsequent evaluative interviews. As previously highlighted, this co-design process was not focused on generating new products but rather on better discussing and framing the troubles surrounding SHTs, raising awareness and critical thinking among people participating. By emphasising mutual learning and democratic participation, this research addresses the systemic injustices inherent to current SHT development. It expresses the transformative potential of co-design as a methodological and conceptual tool.

This thesis demonstrates how the diverse ways in which SHTs are imagined can be activated by discursive and reflective methodologies. Such *imaginaires* can trouble sociotechnical systems currently maintaining an uneven distribution of technological benefits and risks. In doing so, this co-design research empowered participants to articulate alternative *imaginaires* and interrogate the systemic challenges associated with SHTs, including usability, production and consumption dynamics, and the broader relationships between people and technology.

1.3. Thesis Structure

This introductory chapter has set the course for a detailed exploration of co-design, its outcomes, and its implications for a more responsible development of smart home technologies. Chapter 2 presents the theoretical context in which this research has been

developed. Presenting the many ways in which smart homes and their technologies have been imagined throughout the years, the chapter highlights the social and environmental consequences of an irresponsible development of smart technologies, guided by a lack of diverse narratives among dominant industry players and the solutionism in technology push. Forms of regulation and governance have been tested in the past to make the development of SHT more responsible. The chapter will detail the methods of inclusion in technology design, like participatory design, user-centred design, and co-design. Even with previous studies demonstrating interest in changing smart home technologies' current design and development through inclusion, they fail to make it more diverse and reflective. The chapter then concludes by demonstrating the transformative potential of co-design in making sociotechnical systems more responsible and just and introduces the research questions this thesis intends to answer.

The methodological procedure of this research is described in Chapter 3. Positioning the research philosophy as co-design, the chapter details a research design organised around the ethical commitment of including the public as partners and not subjects. Respecting that, the thematic sampling strategy was characterised by three participants' profiles: first, a group composed of professionals working to develop smart home technologies; second, a group with early adopters of said technologies; and third, a group with late or non-adopters of smart technologies. This will be followed by the introduction of the four main phases of the research design: from an exploration of participants' SHT *imaginaires* to a description of speculative interventions capable of affecting the current discourses surrounding the development and use of SHTs, which is continued by a prescriptive discussion on impacts and risks of each speculative intervention. A final evaluation of the whole co-design process concludes the research design. Data collection methods for each phase are also detailed, along with the thematic and visual analysis methods used.

With the aim of diversifying inclusion in SHTs research and development, Chapter 4 reports on the analysis of the data collected in the first phase of the study, characterising the dominant *imaginaires* behind current smart home technologies. Starting with participants' definitions of smart homes, the first section describes the types of technologies and the instrumental value each group associated with smart homes. The second section synthesises the dominant aesthetics that each sample group related to smart homes. Followed by the knowledge, experiences, and images participants referred to when imagining their smart homes. Finally, through a comparative analysis, I claim that the supposed gap, or contrasts, between SHTs *imaginaires* are not deep enough to justify the irresponsibilities in how SHTs are developed today. Instead, the common elements in their standardised, flat *imaginaires* still mirror a techno-positivism initiated in the 19th century. To challenge such narratives, I emphasise the specific tensions and oppositions across their definitions, aesthetics and experiences of SHTs in a deliberate move to raise trouble in the subsequent phases of the co-design process.

Chapter 5 reports on data analysis conducted during the second and third phases of the research design—such phases correspond to a non-solutionist co-design. The first section elaborates on participants' priorities for future development and use of SHTs. Those were the requirements each group respected during their co-design process—they aimed at staying with the troubles to understand them better instead of targeting technological solutions. The second section elaborates on the tensions and oppositions between SHTs *imaginaires* identified at the end of Chapter 4. The most common troubles considered by participants are presented in three main categories: product-related troubles, regulatory troubles, and broader, systemic troubles. Respecting their priorities, the third section introduces the co-designed speculative interventions participants developed to stay with the complexities and incoherencies of today's smart home technologies. This was essential for participants to understand the potential benefits SHTs can provide and the collective responsibility to govern undesirable risks. The ways in which participants speculated on the different types of troubles and the scope of the elements being priorities revealed the co-design transformative capacity to approach and challenge different levels of a sociotechnical system.

Chapter 6 reports on the analysis of data collected in the fourth and final phase of the research design and reflects on the potential of a non-exploitative, democratic co-design practice for enacting more responsible and just development and use of SHTs. Based on interviews and participants' feedback, the chapter evaluates three essential aspects of co-design transformative potential: the power dynamics encompassed by co-design, an accessible and engaging participatory infrastructure, and the focus on mutual learning (rather than product improvement). The first section elaborates on the need to balance power dynamics encompassed by the co-design process, which refers to including diverse social groups in an open conversation so participants can reach common objectives. The second section focuses on the organisation of an accessible and engaging participation infrastructure. In the case of this research, the use of visual and sensory methodologies provided such an infrastructure. The third section then focuses on the purpose of co-design and argues that, in order to be transformative, co-design should facilitate mutual learning between participants instead of product improvement. I close the chapter by arguing that pursuing all these three aspects can make co-design more responsible and just. Attending to these concerns can enable co-design to better inform decision makers accounting for diverse perspectives, revamp stakeholders' relationships through an improved participation infrastructure, and empower participants to challenge dominant *imaginaires* through mutual learning.

Chapter 7 concludes the thesis, recalling how previous chapters advanced the research arguments and answering the research questions. The three key contributions of this research are then summarised: first, the thesis takes a conceptual distance from solutionism, with the focus on better understanding troubles instead of looking for rushed technological solutions; secondly, by enacting a focus on tensions and oppositions through co-design, the thesis presents a novel methodological approach to the study

of smart home technologies; thirdly, with the co-designed speculative interventions encapsulating a systemic understanding of SHTs troubles, the thesis makes an empirical claim that co-design needs to be contextualised in broader social, economic, and political structural changes for it to achieve its transformative potential. The conclusion also highlights how the conceptual, methodological, and empirical contributions can impact the actions of industry practitioners, academic researchers, and policymakers. Closing the thesis, I suggest future research should follow three main streams: (i) make better use of trouble and chaos not only as a form of distancing from solutionism but also as a strategy to incorporate contrasting and opposing perspectives in design; (ii) in the future, co-design should be seen as a systemic practice that encourages personal revolutions through critical consciousness; (iii) finally, future research must understand that if co-design is not accompanied by broader, structural change in sociotechnical systems, there is a risk that the process will be no different from non-participatory, traditional design.

2. Literature Review

Recent developments in Artificial Intelligence (AI) computational models have reinforced the presence of digital technology in civic, economic, and political life. The new frontier for the consumer technology market is the intimacy of domestic life. In the last two decades, smart home technologies (SHT) have been developed for comfort, entertainment, and assistive ends (Chan et al., 2008). The technology has also become popular because of its potential relevance in facing global challenges such as climate emergency (Gram-Hanssen and Darby, 2018).

Historically, the United Nations' Intergovernmental Panel on Climate Change (IPCC) has been releasing official reports detailing climate change mitigation and adaptation actions strongly supported by Information and Communication Technology (ICT). In general, with some vocabulary variation, from 1990 to 2022, smart technologies have been mainly prescribed to reduce energy consumption and allow the distribution of a variety of renewable energy sources (Edenhofer et al., 2011; Intergovernmental Panel on Climate Change, 2023, 2015, 2007, 1996, 1993, 1990). These measures are expected to help households from industrialised countries to gradually rely less on fossil fuel and carbon emissions. Consequently, many countries have started to deploy incremental smart devices focused on energy use feedback and demand, like smart meters (Ballo, 2015; Bugden and Stedman, 2019; Hargreaves et al., 2013).

Moreover, the deployment of a standard connection protocol (Matter) and faster Internet networks (5G) have been having a noticeable impact on the smart home market. A Statista report (2024) projected the worldwide revenue to reach US$231.6bn by 2028. The same report ranks the United Kingdom as where SHT has better penetrated the consumer market, with 62,4% of British households being automated with at least one smart device. Among wider technical availability and consumer markets, SHT's adoption growth has also been associated with longer indoor hours during and after the COVID-19 pandemic (Woods, 2024).

Due to its disruptive nature, SHT's impacts are expected to go beyond technical and environmental systems, modifying the social practices present in domestic everyday life. Besides the potential benefits, SHTs (and AI in general) have already demonstrated their risks in reinforcing existing socioeconomic burdens, creating new forms of inequality, surveillance, and resource-intense demands. A responsible and just design of SHT can better guarantee the technology's benefits and the proper governance of its risks.

For that, this chapter intends to elaborate on a genealogy of ways in which SHTs have been imagined since electrification, detailing some of the irresponsible outcomes associated with a solutionist technology design. Then, responsible research and innovation frameworks are presented, arguing in favour of the inclusion of affected people in technology design. The chapter then reviews previous collaborative designs of SHTs, where I argue that, for a more just distribution of technological benefits and burdens with accountable stakeholders, technology design needs to focus on the troubles surrounding smart homes.

2.1. Imagining Smart Homes

Smart homes have been imagined in many ways, and their technologies are being adopted in equally diverse forms. The modern imaginary, funded by science and technology trust, has reached its highest point with AI inhabiting the home and generating new interactions with householders—consequently affecting their subjectivities. An imaginary, or, in French, *imaginaire,* is defined by Wunenburger as a "set of productions, either mentally or physically manifested, based on visual images (painting, drawing, photograph) and linguistic expressions (metaphor, symbol, story), forming coherent and dynamic sets," capable of affecting the process of giving meanings to things and ideas (2020, p. 11). "*Imaginaires* are part of how one perceives and constructs things and ideas, while experiencing visual and metaphorical expressions in everyday life." (Pereira and Hargreaves, 2024, p. 3)

The representations of things and ideas that an individual has empirically experienced can determine how such individuals define, approach, and relate to those things and ideas. This ontological characteristic of *imaginaires* (Bachelard, 1971) can be exemplified in the context of this research: householders' contact with SHT representations and their interactions with smart devices not only comprehend the structure of references they carry as their SHT *imaginaire* but also as their *imaginaire*, it is their framework for what they expect smart homes to be and technologies to do.

For Gilbert Durand (2016), visual and linguistic narratives composing the *imaginaire* of socially powerful groups can be made durable throughout time in productions (visual images and linguistic expressions). The relevance of studying such productions is in unveiling the origins or original expressions of an *imaginaire*, as well as the dominant social discourses making it last in contemporary *imaginaires*. Therefore, uncovering the

imaginaires that have been animating the development and use of SHT is essential to better understanding the extent of the impacts the technology can have on future social, economic, and environmental systems.

2.1.1. From Electrification to Artificial Intelligence

At the end of the 19th century, representations of electric mechanical house automations started to populate people's *imaginaire*. A modern technological-driven domestic ideal was initiated, relying on the unprecedented technical availability of the First Industrial Revolution and an intense social transformation following modifications in the European colonial economic model—e.g., the end of the international slave trade (Woods, 2024) and the consequent shortage of domestic servants for middle- and upper-class households (Aldrich, 2003). In the early years of the 20th century, for those who could afford it, home electricity could replace servants' physical strength with "time-saving" goods: using a "vacuum cleaner, refrigerator, washing machine, and dishwasher," (Nyborg and Røpke, 2011, p. 1850) individuals—usually women—were promised to be able to perform all household chores alone and still have leisure time (Aldrich, 2003). However, the efficiency of electric appliances resulted in new energy consumption demands—e.g., more access to cleaning has increased cleaning standards, with women cleaning more often.

Home automation was then re-imagined at the end of the 20th century with the advent of electronic components powering domestic appliances with information processing capabilities. A post-war and globalised market has brought theoretical and material innovations to the home. Echoing rationalist and functionalist discourses of a "machine for living" (Corbusier, 2007)[1], large urban housing complexes sheltered an increasing number of consumer-householders, while microprocessors, sensors, and actuators in appliances promised to "monitor, manage, and manipulate" systems in the home even from a distance (Nyborg and Røpke, 2011, p. 1850). In this "intelligent objects" smart home *imaginaire* (Aldrich, 2003), the focus transitioned from technology replacing physical strength to enhancing cognitive capacities (Nyborg and Røpke, 2011). With appliances occupying "discretionary time and improving its perceived quality," (Aldrich, 2003, p. 27) there was an opportunity to explore other forms of home automation—like fire and burglar alarms for home security systems, ambient conditioning and energy being electronically managed, and assistive equipment improving the welfare of people with disabilities (Nyborg and Røpke, 2011).

1. Industrialisation and mechanisation of construction was essential for modern architectural discourses like the functionalist international modernism style of Le Corbusier, the concrete technology in brutalist, and the slim glass and steel mid-century buildings from North American architecture (Cohen, 2012). Modern architecture was a suitable scenario for the futurist discourses of the 20th century due to its contrast with traditional and vernacular architecture. Because of that, the movement has also been targeted as an epitome of the unrestricted modernisation of everyday life. Feature films like "Mon Oncle" (1959) and "Playtime" (1968), both by French director Jacques Tati, illustrate this critic of the modern, futuristic life.

The popularisation of personal computers and access to the World Wide Web triggered new home automation *imaginaires*. Mark Weiser described an ambience with fully computerised appliances in his theory of calm and ubiquitous computing networks (1993, 1991; 1999). The author envisioned a "constant" communication between devices, "invisible" to everyday awareness (Weiser, 1999, p. 3). In this *imaginaire*, the "intelligent objects" communicate with each other—like personal computers via the Internet—exchanging information to perform household tasks or run timed routines (Aldrich, 2003). The wireless communication between devices has been called the Internet of Things (IoT) (Sterling, 2014), and following the ubiquitous computing paradigm, has been connecting SHTs with a discreet visual presence: "They weave themselves into the fabric of everyday life until they are indistinguishable from it." (Weiser, 1999, p. 1) As one could expect, a variation of such an *imaginaire* can also describe such "intelligent objects" as not only communicating within the same house but also being able to expand and connect to the Internet, allowing remote control and access to other services (Aldrich, 2003).

The accumulation of digital data and the ascending processing power in the first decade of the 21st century rekindled connectionist theories of AI, trying to reproduce the electro-chemical phenomenon of a human brain with computers. The most popular computational model developed during this period was Machine Learning (ML), which uses digital data to train statistical inference algorithms. This computational model can "predict" the future states of a system, igniting *imaginaires* of a "learning home" (Aldrich, 2003). With recent developments in Generative Artificial Intelligence (GenAI) technologies reaching the consumer market, this *imaginaire* can be further explored into what Aldrich named "attentive homes": a smart home that would anticipate its occupants' needs, constantly learning with the house routines. For the author, the different ways to imagine a smart home and their technical feasibility are hierarchically associated. For example, a learning home wouldn't be possible without the sensors and IoT in a house with intelligent objects, which, consequently, wouldn't be possible without electricity. However, for Aldrich, "If a paradigmatic shift in the way we live with domestic technology is going to occur, [he] suggests that it is the implementation of the fifth level of smart home, the Attentive Home." (2003, p. 42) After 20 years of Aldrich's publication, most definitions of SHTs today refer to technology between Learning and Attentive Homes, with the paradigmatic shift already modifying everyday life.

The various ways in which individuals and institutions imagine smart homes can also directly influence the adoption of technology: "Not all individuals in a social system adopt an innovation at the same time." (Rogers, 2003, p. 241) People develop distinct strategies and timeframes to adopt a new technology according to their social values, belief systems, financial availability, age, and other personal characteristics—just like their positionalities and experiences inform their *imaginaire*. Early adopters of emerging

technology, for instance, might be willing to take additional risks compared to sceptic late or non-adopters, who may prefer to wait until the benefits are clearly stated and guaranteed.

Another aspect associated with different SHT *imaginaires* relates to the technology's direct installation and use. According to the ethnographic visits to smart homes in the United States, Woods (2024) describes three main types of smart homes in terms of how the house was designed and the perceived instrumental value of the technology. The first type is a home "designed to be smart" from scratch. They usually present traditional architecture and keep the smart technology "silent" as an infrastructure. This type of smart home also reinforces traditional domestic values. A second type is associated with experiments and living labs, where people are testing prototyped smart technology and are open to trialling new forms of domestic life. The third type described is the do-it-yourself retrofitted home with smart additions. Occupants would usually need to dedicate more time and develop digital skills.

Through the evolution of house electrification, procedural automation, and AI-powered devices, "the smart home can be seen as a melting pot where different trends meet, influence each other, and sometimes merge." (Nyborg and Røpke, 2011, p. 1850) According to Jiang et al. (2004), a smart home contains three foundational elements: an **internal network** to connect all devices and sensors (like IoT protocols); **intelligent control,** creating an interactive interface between inhabitants and the network (like GenAI-enabled control and interactions); and a home **automation ecosystem**, populating the house with devices presenting different and complementary capabilities (like smart speakers and sensors). Here, based on the current GenAI automation paradigm, the present research will consider that a home can be perceived as smart if, relying on specific hardware and software, it's able to collect household data, process it, and take actions based on data interpretation (Cook, 2012). Irrespective of the ways in which the house has been designed or retrofitted, for this research, smart homes present an apparent intelligence when interacting with householders.

Different sociotechnical paradigms have enacted different smart home *imaginaires* in individuals adopting them or not. The different ways of imagining the technology have iteratively influenced its development. The coexistence of different perceptions of the same technology is usually positive for maintaining diversity in natural and artificial systems. However, the imposition of specific *imaginaires* over others can have irresponsible outcomes associated with technology deployment.

2.1.2. Irresponsible and Smart

Dissonant *imaginaires* between social groups are part of power structures able to relay some representations as dominant and others as valueless. The benefits and burdens associated with SHT development respond to such a power dynamic—and, with an

uneven distribution, SHT's benefits end up reinforcing some individuals' privileges whilst keeping others in an even more vulnerable position in a hyper-digitised everyday life. Scholars and media are already documenting the impacts of such techno-led discrepancies. Impacts on domestic everyday life go from devices being racist and sexist to deepening the digital divide because of financial cost and digital skills, reaching generational forms of exclusion. SHT also impacts the perception of privacy in and outside the home, pushing an unsafe narrative that creates a new demand for uninterrupted surveillance. Even the planetary benefit of smart energy seems to come with higher costs on natural resources to make it technically functional. This section will introduce the three main irresponsible outcomes associated with the mass deployment of smart home technologies related to deepening social inequalities, spreading pervasive surveillance, and worsening environmental impacts.

AI-powered Inequalities

ML statistical computational models can infer future states of a system based on previously collected digital data—a "learning" process with or without the presence of a programmer. In supervised learning routines, programmers feed the models with training data. For instance, a smart thermostat might learn householders' preferred temperature according to previous settings inputted. In contrast, the algorithm presents more autonomy in gathering, processing, and organising data for their training in unsupervised learning—relying on complex algorithm architectures (e.g., deep learning, neural networks), sensory hardware, and refined communication protocols. The smart thermostat can interpret who and how many people are in the house, where they are, energy supply availability and cost, etc.

Even if this automation technology presents great potential for streamlining domestic routine, there has been evidence of the risks of ML algorithms getting biased during their training procedures, which leads to harmful outcomes for adopters and non-adopters of smart technology. It is known today, for example, that voice assistants like Alexa and Siri "understand black people less frequently than they understand white people." (Quaglia, 2020) The system's performance rate also drops when users present an accent different from standard English or a high-pitched voice usually associated with female users (Bajorek, 2019). Speech recognition technologies are the most common interface in smart home gadgets and are also being deployed in structural sectors such as job hiring, transportation, and immigration systems (Bajorek, 2019). For instance, an Irish woman received a low score on an automated spoken English proficiency test, preventing her from immigrating to Australia even though English was her first language (Bajorek, 2019).

It is not difficult to track home automation back to colonial and slavery times (Woods, 2021). The shortage of domestic servants that eventually contributed to the popularity of electrical home appliances reflected the decadence of an exploitative labour system. Back

in the 19th century, in the electrification *imaginaire*, women (mostly women of colour) were socially expected to perform household chores. Meanwhile, men (mostly white men) enjoyed the privilege of adventuring themselves in work and technical innovations. In many ways, this binary gender dynamic hasn't changed. Most people who are researching and developing AI computational models like ML are white men (Wang, 2020). Even if historically women have been expected to perform housework, they "have long been disenfranchised from the development of the domestic technology they use." (Aldrich, 2003, p. 25) Male developers can bias technology development towards users similar to their image (Aldrich, 2003; Strengers and Kennedy, 2020), powering up existing "deeply problematic gender stereotypes" with smart devices (Baraniuk, 2022). The racial and gendered inequities embodied in smart speakers can end up harming populations who are already marginalised by dominant groups, deepening prejudices and divides.

Privacy, Security, and Surveillance

In Weiser's initial framing of ubiquitous computing, the author mentioned privacy as a critical social issue that ubiquitous computing can engender (1991, p. 7). Later, Aldrich highlights that, at the end of the 20th century, most of the apprehension about adopting home technologies was related to who controls it (2003). In 2020, approximately 30 people sued Amazon after having hackers invading their 'Ring' security devices.[2] Users mentioned "hackers taking over Ring cameras, screaming obscenities, demanding ransoms, and threatening murder and sexual assault." (Paul, 2020)

What wasn't anticipated by scholars is that some SHTs wouldn't need to be hacked for it to trouble householders' everyday lives: "It could be a former partner, a jilted lover, a stalker, a former lodger or just someone you know who has a grievance." (Naughton, 2018) They wouldn't need to invade the systems, as they know the password. Smart devices are now used for harassment, monitoring, and revenge: "Abusers would remotely control everyday objects in the home, sometimes to watch and listen, other times to scare or show power," (Bowles, 2018) intensifying coercion and control within abusive relationships (Braithwaite, 2018). One of the first cases of IoT technology being used to abuse a partner was registered in May 2018, when a 35-year-old electronic expert was convicted of stalking and listening to his estranged ex-wife's conversations (Lopez-Neira et al., 2019). It's common to find men managing SHTs in a house. Due to uneven educational opportunities and social expectations, women have been made vulnerable in relation to men when it comes to the lack of digital skills necessary to update and modify smart systems after a separation (Khan, 2023).

Home security is a popular market appeal to sell smart home products. After becoming pervasive indoors, companies aim to provide devices facing the outwards (CBC Radio, 2019). For instance, smart doorbells are advertised as a security and convenience

2. Ring is a North American home security and smart home devices company, founded in 2013 and acquired by Amazon in 2018, being kept today as a subsidiary of the Seattle-based big tech.

addition to a household's daily life. The number of devices installed in houses in the US is already considered the "largest corporate-owned, civilian-installed surveillance network." (Bridges, 2021) Media highlighted that smart doorbells are more likely to label people of colour as "out of place" or "suspicious" in wealthy and predominantly white residential areas (CBC Radio, 2019; Molla, 2019). The result is that, instead of promoting safety, smart technology promotes neighbourhood surveillance platforms, perpetuating "a much longer history of the policing of race in residential space." (Bridges, 2021) Like the police being called on an African American real estate agent because neighbours thought "it was suspicious for him to ring a doorbell." (Keenan, 2024) In this case, more surveillance cameras mean less safety for already marginalised communities (CBC Radio, 2019). Once again, smart technology is worsening existing concerns over privacy and security.

Resource-intense Demands

Research on energy efficiency and transition has raised interest in using smart technologies. To better understand and analyse natural resource consumption, SHTs are also expected to contribute to the social dynamics surrounding climate crises, fostering practices of sustainable behaviour among householders (Morley et al., 2016). However, the AI computational models powering smart technologies rely on energy- and resource-intense data servers (Amanta, 2024), responsible for "carbon emissions from non-renewable electricity and the consumption of millions of gallons of freshwater." (Berreby, 2024) Estimates say that data servers powering the Internet are already as pollutant as the airline industry, and "Some predict that server electricity use will treble in the next decade." (Morley et al., 2016) Moreover, because of the lack of transparency (Berreby, 2024), it's not possible to consistently measure how much freshwater is necessary, for instance, to run a smart speaker voice request.

On the other hand, consumer electronics are being offered in unprecedented numbers. The number of plugged-in devices in a smart home can generate new energy demands (Nyborg and Røpke, 2011), including "powering the devices themselves." (Morley et al., 2016) Planned obsolescence is an increasing problem for sustainable practices, and the seasonal release of new devices increases the number of electronic waste (Baldé et al., 2024).

The potential support SHT is supposed to provide in the energy transition has also been challenged. It's now known that behavioural changes in energy consumption tend not to last long enough (Nyborg and Røpke, 2011). Smart energy technologies can "support the creation of entirely new energy-demanding practices and change consumption dynamics,"(Nyborg and Røpke, 2011, p. 1858)—just like electric appliances have generated higher cleaning standards in the 20th century (Morley et al., 2016). With more information about consumption and the fluctuation of energy rates, people tend

to concentrate their appliances' use in cheaper hours, causing peak demand. Knowing when the energy is more affordable has also led people to use more energy (Gurzu, 2017), generating a rebound effect (Amanta, 2024; Berreby, 2024).

Even though smart home technology has the potential to support sustainable practices, the manufacturing and use of an ecosystem of smart devices at home can also lead to severe and multiscale consequences. From AI deepening inequalities to pervasive surveillance and environmental costs, the consequences of SHT mass adoption are usually opaque in the *imaginaires* of those developing the technology. The irresponsible outcomes become tactile when it is already too late, affecting public perception of the technology and undermining any possible contributions it could bring.

2.1.3. The Design of SHTs Today

The current design of SHT seems to lack a consistent framing of possible risks and negative consequences rushing to launch attractive smart devices to the consumer market. SHT's harmful outcomes are not a unidimensional problem but a product of a complex sociotechnical system and limited *imaginaires* that privileges dominant discourses associated with wealth accumulation through science and technology positivism.

Lack of Diverse Imaginaires

Modern representations of smart homes have been inhabiting collective *imaginaires* for decades, and even knowing that smart devices can change how people inhabit their domestic spaces (Edwards and Grinter, 2001), research and innovation resources have been mainly allocated for their technical possibilities (Aldrich, 2003; Gram-Hanssen and Darby, 2018; Leitner, 2015). According to Leitner, (2015) there is a gap across the computer sciences and social sciences approaches to SHTs, i.e., a distance between the technical and the social/humanities perspectives. The social consequences of the technology are not only being overlooked but the discourses and values animating the technology also remain opaque and unchallenged.

With the premise that "It matters what stories make worlds, what worlds make stories," (2016, p. 12) Donna Haraway argues that knowing what thoughts and stories produce our troubled times is essential, signalising the importance of understanding what is behind the decisions that strongly influence our sociotechnical systems. Previous research on sociotechnical systems (Bijker et al., 2012; Cruz, 2017; Feenberg, 2002) has demonstrated how social factors play an essential role in technology development —let alone how artefacts can reinforce political discourses (Winner, 2020), such as the bias in AI computational models (Mittelstadt et al., 2016). The development of algorithms is not neutral but a reflection of its developers' values and belief systems (Mittelstadt et al., 2016).

The rapid growth of structured knowledge and the initial moments of modern science between the end of the 19th century and the beginning of the 20th century, alongside the development of an industrialised society, have produced an *imaginaire* of digital technology as a liberating force that could be used to change the future as desired (Verschraegen and Vandermoere, 2017). In its early electric stages, home automation, as we have now, was not technically feasible. Most visions and representations of such technology relied on the fiction of what a scientised society could achieve. The possible benefits of technical solutions were usually broadly publicised and unbounded, while risks were contained and not made explicit—framed as limited and manageable (Jasanoff and Kim, 2013).

Technical positivism and developmental ideals were reinforced in 2016 during the World Economic Forum (WEF) annual meeting, where a Fourth Industrial Revolution (4IR) was predicted (Schiølin, 2020). According to the WEF committees, the changes a connected digital economy could infer over society indicate a new revolution (Schiølin, 2020). One of the most relevant aspects of this new era is the development of AI. The premise of this computational model is aligned with the liberating *imaginaire* of the full support of a customer's life, making daily routines easier (Hargreaves et al., 2018).

Smart home technologies have been developed by industry's technological push, anchored in an individualistic *imaginaire*, populated by economic Western values of capitalism and liberalism, building a supposed free modern society. However, these are the values of socially and economically dominant groups. Groups already benefiting from the technical availability are constructing smart technologies to reinforce an uneven power distribution. It seems reasonable to state that the industry's positivist *imaginaire* is the one constructing smart technology—a corporate vision generated by dominant social groups that lacks representation of individuals' visions affecting and being affected by SHTs.

Technology Push and Solutionism

Any new technology added to a home is capable of disrupting its routine, so it seems logical that such changes should aim to benefit householders (Edwards and Grinter, 2001). However, there's still a small participation of people affected by SHT in its development. Instead, the industry's technology push has been the approach for smart home technologies—a development and growth paradigm justified by technical feasibility instead of what adopters desire (Aldrich, 2003).

This dominant perspective is usually accompanied by solutionism (Morozov, 2013) or the urge to find technological fixes for any issues without carefully considering the problem in the first place—risking generating technology without an apparent demand from consumers. As Haraway indicates, in the hasty attempt to solve poorly framed sociotechnical troubles, one risks generating "techno-fantasies" and utopias that can

aggravate existing troubles or even create new ones (2016)—i.e., solutionism supported by industry's positivist *imaginaires* is contributing to the irresponsibilities presented by SHT associated with techno-powered inequality, privacy and surveillance risks, and environmental costs.

Instead of creating new and aggravating existing social, economic, and environmental issues, Donna Haraway calls for "staying with the troubles" (2016). The author defines "troubles" as "global challenges" currently faced by society (Søndergaard, 2020)—from climate change to territorial and resource wars. For this research, troubles will be read as "global instances of tension, opposition, contestation and resistance" to smart technologies, as described by Sharma et al. (2023). SHTs are troubling householders' everyday lives and consumption patterns across industrialised territories, evidencing the house as a digital data production space, an asset in the platform economy of late capitalism (Couldry and Mejias, 2019; Zuboff, 2019). Instead of a technology design process focused on technical solutions, the development process should better elaborate on the troubles being dealt with.

There is a need to transform the current development of SHTs to include the people who are going to be affected by its deployment. Responding to the way smart technology is designed today, I argue that this transformation can be triggered in two complementary ways: firstly, a more robust conceptual framework must be included to support alternative, diverse *imaginaires* in the technology development process. Secondly, a transformative process should allocate time to a thorough understanding of technology problems, their origins and causes, and not rush to find suitable solutions. In summary, technology design must be more transparent and inclusive, and the next section will start framing how it could be done.

2.2. Responsibility Through Participation

Smart home technologies can modify social, technical, and environmental systems and, for that, can be seen as disruptive technology. Resonating concepts of the social co-construction of technology (Bijker et al., 2012), Haraway calls for a collective form of responsibility, as all social actors have played a part in the undesirable outcomes experienced today through disruptive technology:

> "We are all responsible to and for shaping conditions for multispecies flourishing in the face of terrible histories, and sometimes joyful histories too, but we are all response-able in the same ways." (Haraway, 2016, p. 29)

Studies on previous disruptive technology development have been conducted to understand how to regulate and govern projects with such transformative potential more responsibly. They enact the collective responsibility for technology's undesirable troubles as they assume that opening research and innovation for the participation of the external public can help prevent harmful outcomes.

2.2.1. Inclusion in RRI Approaches

Smart home technologies have the potential to be quite disruptive in the sense that their ubiquitous use can transform different systems in society and the environment. Historically, many disruptive research and innovations have caused harmful impacts. Because of that, the governance of research and innovation became an essential practice in tackling unwanted outcomes.

In the early stages, there was a retrospective governance of impacts. Identified as "external" (Stahl and Coeckelbergh, 2016, p. 153), the impacts were regulated after they had happened. Another way to identify the impacts is "internal" (Stahl and Coeckelbergh, 2016, p. 153) and relative to an ethical practice during design and research. Stahl and Coeckelbergh argue that the introduction of Responsible Research and Innovation (RRI) frameworks in the 2010s filled the gap between internal and external governance (2016). The focus here is then to govern potential implications in the early stages of research and innovation instead of waiting for adversities to rise after deployment.

Owen et al. highlight the necessity of collective discussions and deliberation to decide on the "right impacts" that should be prioritised, mentioning that: "We [as individuals] care about what is of constitutive value to us, mediated through our attachments, identities, beliefs, and the various roles we play, and the influences which bear, and which have had a bearing upon our lives." (2013, p. 37) When read through the concept of *imaginaire*, what individuals value is connected to how and what constitutes their *imaginaires*. Contrasting with the current development of smart home technologies, a responsible process would account for people's *imaginaires*, belief systems, and social values affected by the technology.

A popular RRI framework was the one presented by Stilgoe, Owen & Macnaghten (Owen et al., 2013; Stilgoe et al., 2013), based on the understanding that RRI is "where science and innovation are directed at, and undertaken towards, socially desirable and socially acceptable ends, with connotations of trust and integrity." (Owen et al., 2013, p. 27) The authors propose that stewardship of research and innovation should include reflection and public deliberation about impacts and the initial *intentions* and *purposes* of the research and innovation (Owen et al., 2013)—not only *what* is being researched but also *why*. For them, "Responsible innovation is a collective commitment of care for the future through responsive stewardship of science and innovation in the present." (Owen et al., 2013)

Their framework presents four structuring principles: anticipation, reflection, responsiveness, and inclusion. Through systemic thinking (Stilgoe et al., 2013), technology assessment, and scenario development (Owen et al., 2013), research and innovation should be able to **anticipate** the intended and potentially unintended impacts that it might trigger (Owen et al., 2013; Stahl and Coeckelbergh, 2016) Researchers and innovators should be able to **reflect** on the purposes of, motivations for, and the anticipated implications of their work. (Stahl and Coeckelbergh, 2016) The value systems and *imaginaires* can shape their decisions (Stilgoe et al., 2013) and the "associated uncertainties, risks, areas of ignorance, assumptions, questions, and dilemmas." (Owen et al., 2013, p. 38) As described by Stilgoe et al., "Responsible innovation requires a capacity to change shape or direction in response to stakeholder and public values and changing circumstances." (2013, p. 1572) Hence, the process should be open and dynamic (Owen et al., 2013) instead of fixed and "locked" (Owen et al., 2013, p. 35). Being **responsive** requires an active position from researchers and innovators to adapt the process's direction and trajectory (Stahl and Coeckelbergh, 2016).

All of this is only possible by **including** other people in the process. Opening up research and innovation's visions and impacts for questioning or deliberation (Owen et al., 2013; Stahl and Coeckelbergh, 2016). Besides stakeholders, the intention has been to include the broader public through dialogue, engagement, and debate (Stilgoe et al., 2013): "This allows the introduction of a broad range of perspectives to reframe issues and the identification of areas of potential contestation." (Owen et al., 2013, p. 38) Including people affected by innovation in its development process is part of many RRI frameworks. The deliberation between multiple stakeholders can provide more careful consideration of potential flaws and the anticipation of implications. In this research, the inclusion of the external public affected directly or indirectly by SHTs can better represent the current overlooked diverse *imaginaires* in the development of the technology.

Stilgoe, Owen & Macnaghten's framework is the basis for many research funding bodies to encourage more responsibility in the supported research project. This is the case of the UK Research and Innovation's official RRI framework called the AREA—an acronym for Anticipate, Reflect, Engage and Act (UKRI, 2023). Exploring the UKRI AREA framework in the use of robotics in health care, Stahl and Coeckelbergh have formally contrasted the dimensions of anticipation, reflectivity, inclusion, and responsiveness with what they have called 4P's:

> "Process: covers all activities in preparing research, undertaking data collection and analysis, storage and presentation of data and interaction with respondents.
>
> Product: can refer to products or services. It includes the consequences of use as well as misuse of research products and the impact that research has on the natural and social environment.
>
> Purpose: covers the question of why research is undertaken at all.

> People: are at the heart of RRI and need to be explicitly considered." (Stahl and Coeckelbergh, 2016, p. 156)

Overall, frameworks are interested in including and participating stakeholders and the public in different moments and contexts. Thus, it can be assumed that RRI relies on the notion that more narratives, *imaginaires*, and needs must be included to achieve responsible research and innovation. But that might not be enough.

Authors reviewing the practice of RRI have identified gaps or limitations when enacting framework principles (Reijers et al., 2018). The diverse ways of engaging or including stakeholders, as well as the different levels of engagement that they can present, are points identified by Schuijff and Dijkstra (2020). The authors highlight that achieving broader discussions on moral, ethical and social matters (Schuijff and Dijkstra, 2020) can be challenging without carefully designed methods. Because of that, those perspectives are often left behind, risking RRI practices becoming vague (Schuijff and Dijkstra, 2020). As stated by Pallet et al., vague RRI inclusion practices "risk becoming a procedural or social 'fix' for the problems of technology." (2024, p. 4) Going further, Owen et al. acknowledge that even though categorising an anticipated impact as "right" doesn't mean that it wouldn't, in the end, be reinforcing the status quo of a "capitalist project of modernity" which is no longer sustainable. Hence, they point out that RRI should not be separated from its political and economic context—not ignoring the "inevitable tensions, dilemmas, and conflicts" that can emerge from it (Owen et al., 2013, p. 37).

Van Oudheusden presented an early critique of popular RRI frameworks, highlighting the lack of a political discussion to support its principles (2014). Their paper defines politics as the dynamics involved in the "constitution and contestation of power." (2014, p. 67) It indicates that, following the constructivist roots of RRI, the prescribed way of assessing power dynamics is through public engagement/deliberation in a post-normal participatory science. However, the same frameworks are pondered in ideal "arrangements of power and technique, which typically rest on a vision of true democracy as a deliberative, cooperative, and broad way of dealing with social conflicts, and the conviction that social learning is morally superior to political bargaining," (van Oudheusden, 2014, p. 72) forsaken topics like the authoritative allocation of values or top-down research tradition.

A growing body of literature (Albertson et al., 2021; Koch, 2020; Levidow and Papaioannou, 2018; Owen et al., 2021; van Oudheusden and Shelley-Egan, 2021) has been further elaborating on the lack of social justice in this RRI framework, proposing experiments on the use of theories historically excluded from technological research and innovation, as such multi-species studies (Szymanski et al., 2021), Indigenous cosmologies (Macdonald et al., 2021), Global South perspectives (Wakunuma et al., 2021), and feminist principles (Leonard and Tochia, 2022). Following its political philosophy definition, social justice

ensures a just distribution of technological benefits and costs throughout society (Miller, 2003, p. 84), overseeing a fairer power dynamic between privileged and vulnerable social groups (Costanza-Chock, 2020; Miller, 2003). For the context of smart home technology development, social justice regards a more equitable distribution of the expected benefits and fairer management of potential harms mentioned in Subsection 2.1.2.

So far, this section has been introducing the developments toward assigning more responsibility and justice to research and innovation, especially for those with the potential to disrupt social, environmental, and technical systems. An essential characteristic of such frameworks is the inclusion of external publics, allowing research and innovation to acquire a deliberative and democratic approach. For technology design, inclusion is closely related to the different ways design was framed throughout time. In the search for a suitable method to include diverse narratives in the non-solutionism design of SHTs, it's necessary to better detail the forms of inclusion in technology design.

2.2.2. Forms of Inclusion in Technology Design

Including the external public in technology design precedes RRI frameworks and has influenced the frameworks' understanding that participation of the broader public can offer wider perspectives on anticipating impacts and reflecting on how to tackle them. Many experiments have been conducted for inclusion in design. However, the development of design theory reveals three structuring approaches to creating an open dialogue between stakeholders involved in a technology development process: participatory design, user-centred design, and co-design.

The Rationality in Participatory Design

The roots of design practice are entangled with the social and technical revolutions at the beginning of the 20th century. European Avant-Garde movements got arts and crafts practitioners closer to the possibilities of industrial manufacturing (Galloway and Caudwell, 2018). The organisation of design professional training in technical institutions like the Russian VKhUTEMAS and the German Bauhaus aimed to empower students to design a modern society based on science and technology's objectivity and rationality values (Cross, 2001).

As industry benefited from design's potential to generate goods with an aesthetic allure that "demanded the consumer's attention," (Hocking, 2010, p. 243) the practice can be held accountable for nourishing unsustainable production and consumption practices. However, that was not the only outcome of such a partnership. With industrial manufacturing, the design of electromechanical machinery could count on sophisticated finishings, impossible geometries, and modern materials. All without the medieval shadow of the genius that has always rendered creative practice elusive and esoteric. Design training was then performed in organised and structured institutions that

followed scientific discoveries and technical progress. By 1970, the Design Methods Movement indicated that such a rational take "offered the potential for design to become more transparent and open, extending and making design available to a wider range of people," (Cross, 2023, p. 3) pitching the practice "towards a more complex interconnected notion of the artificial in relation to society and the environment." (Hocking, 2010, p. 243)

Early inclusion theories in design emerged around the same period in Scandinavian countries. Specific socio-political contexts between the 1970s and 1980s led worker unions to organise themselves around the imminent technical changes deployed in their work environment (Bødker, 1996; Kensing and Greenbaum, 2013). Aiming to guarantee that their needs and safety were considered in the workforce's informatisation, employees and industry experienced a collective endeavour known as Participatory Design (PD) (Bødker, 1996; Simonsen and Robertson, 2012). The focus was that the new computer machinery should benefit the workers and support a better work routine. Workers' awareness of the Scandinavian socio-political context echoed other movements across the world aimed at promoting a collective critical consciousness (Freire, 1996).

Following political ideals of sharing the power to decide, the Scandinavian PD can be seen as an attempt to democratise the work environment (Björgvinsson et al., 2010). An affected social group (the working class) demanded participation from the dominant social group (industry owners) in developing new systems and digital technologies to be used by the first ones. The deliberation of priorities and requirements to be met by new technology have been further explored in subsequent PD frameworks, such as in social values-led design (de Vries, 2009; van de Poel, 2015).

Notwithstanding, by the 1980s, the rational paradigm found in the Design Methods Movement and supporting approaches like PD started to be challenged by the very nature of design's creative practice. Linear, objective, and rational design procedures could work on well-defined and known problems. But designers usually deal with "wicked problems" (Churchman, 1967)—complex, poorly framed, ill-defined, ill-structured problems—requiring a set of "reflective practices" developed mainly by trained and experienced designers (Schön, 1986). Such transformation in the understanding of design practice grounded a new form of inclusion in technology design.

The Reproducibility of User-Centred Design

With "The Reflective Practitioner" (1986), Donald Schön offered a constructivist paradigm to better frame design practice as "an interdisciplinary study accessible to all those involved in the creative activity of making the artificial." (Cross, 2001, p. 54) Such perspective allowed theorists to start conceptualising design practice as a mental model, a form of reasoning typical of designers—the "designerly" ways of knowing, thinking, and acting (Cross, 1982). There were many characteristics associated with the designer's way

of thinking, for instance, their solution-focused problem-solving approach (1982, p. 11): designers test possible solutions to a wicked problem (Cross, 2023) to better understand "the limits of the problem and suggest the nature of its possible solution." (Cross, 1982, p. 7) Contrasting to scientists, who analyse the problem first to find the correct answer, designers' solution is a synthesis of the design process (1982, p. 6). Another relevant aspect of a designer's thinking is its constructive tactile nature (Cross, 1982). Designers manipulate materials to respond to abstract requirements and read the values and nonverbal narratives embodied in objects (Cross, 2001, 1982). By thinking with physical artefacts, designers are also fluent in communicating and reasoning with the support of visual representation (Cross, 1982).

While design theory matured in organising its discipline, other fields started to show interest in its transferring skills to deal with their own wicked problems. Part of the designerly ways of knowing has been consolidated outside the field as "Design Thinking," which follows a financial-management trend on design for business, innovation, and entrepreneurship (Cross, 2023). The exportation of a reproducible step-by-step recipe on how to innovate unavoidably holds similarities with the rational design paradigm. Design inclusion made a commercial turn:

> "design thinking for 'your business' started with the customer or user response to products and new product proposals, and later grew into studying interaction design more thoroughly, eventually developing into user-centred design." (Cross, 2023, p. 2)

With the popularisation of personal computing and the early years of the Internet, demands started to emerge from the United States technology industry, which was worried about how their products would be perceived by customers. The field of interaction design was then formulated from the commercial interest in making interfaces more accessible and appealing by consulting the target audience—including users for acceptance and usability trials (Norman, 2013). The focus of User-Centred Design (UCD) (Sanders and Stappers, 2008) is mainly on ameliorating a product for a consumer market through understanding users' behaviours and preferences. Although UCD intends to include users during the technology development process, it does not mean they will be empowered as co-producers of the technical solutions (Kensing and Greenbaum, 2013).

Interaction design is now a mature field branching to service and user-experience design (Cross, 2023), and the concept of developing a design practice around a centred subject became a reference for inclusion in the early 2000s—with experiences from life-centred design to human-centred design and consumer-centred design. UCD approaches are characterised by structured, hierarchical methods placing participants as research subjects—for instance, the modelling of hypothetical idealised users' profiles for testing abstract design proposals. Contrastingly, the democratic essence of PD aims to empower the affected group through awareness and social organisation (Steen, 2013).

The Purpose of Co-Design

As social, political, and environmental issues become more challenging, PD and user-centred design have been influencing each other to the extent that a third terminology is needed. Considered by some authors as an outcome of the contact between the previous two (Sanders and Stappers, 2008), Co-Design can be placed as the contemporary response for inclusion in technology design. Although sharing similarities with the Scandinavian and North American approaches, this thesis is mostly interested in framing their singularities. The most noticeable of them is the co-designs openness to discussing the constitution and contestation of power within sociotechnical systems—something missing in RRI frameworks.

Technocratic material dominance is at the root of PD and user-centred approaches, where both rely on designing new forms of technology to increase work/life quality or the acceptance of a digital product (Sanders and Stappers, 2008). Instead, the contemporary approach of co-design is open to a more holistic view, where the aim is to create a design *for* a purpose—instead of the design *of* a product (Sanders and Stappers, 2008). Nigel Cross stated that the forms of knowing, thinking, and acting specific to design embody a strategic, adaptive, cooperative intelligence for engaging with wicked, multi-dimensional problems (2023).

> "The process of design is a creative way of thinking and doing – what it creates is possibilities for the future: for change, for different functions, aesthetics, and lifestyles, and, ultimately, for facilitating different cultures of living." (Hocking, 2010, p. 244)

The recognition of the coproduction of sociotechnical systems is also part of the context in which co-design emerges. The individual gets relevance in the way it helps compose the collective. Their intentions, purposes, and beliefs are integrated into the design process as participants start to be considered expert partners in their everyday lives. Furthermore, a co-design process can be identified by a list of characteristics described in the literature: first, the process provides a collaborative environment for all participants, with facilitators assuming multiple roles. Co-design is also open to the public's active participation, which allows them to share expertise from their perspective as partners (Kensing and Greenbaum, 2013). Relying on mutual learning of tacit knowledge from participants' everyday practices and design methods and tools (Simonsen and Robertson, 2012; van den Hoven et al., 2015), the process is reflective and open to iterative outcomes that might be re-designed and personalised during its use/deployment (Simonsen and Robertson, 2012). The attempt to define a fixed method for co-design would be contrary to its constructivist roots. However, because it aims for participants' empowerment, a co-design process may present the following phases:

1. Emergence of values: social values emerge from the discussion between individuals (Iversen et al., 2012) in a cooperation that aims to explore conflicting values .

2. Development of values: the emerged values now need to grow into boundaries and orientations (Iversen et al., 2012), requiring curiosity for each other's reality and how the conflict is perceived individually (Steen, 2013).

3. Grounding of values: Rough prototypes are produced to ground the values, making them more tacit and intelligible (Iversen et al., 2012). The group starts to conceive viable alternatives for the conflicts (Steen, 2013) using collective creativity.

4. Realisation of values: Values are grounded in a final design (physical, like an object, or virtual, like a system) that can be tested and refined (Iversen et al., 2012). A reflective process of use and evaluation can assess the development's weaknesses and strengths, indicating the necessary paths for its deployment (Steen, 2013).

Compared to other forms of inclusion in technology design, it's possible to define that co-design can be set in a participatory infrastructure open enough to accommodate fairer power dynamics, valuing mutual learning over product design. Additionally, co-designers do not need to belong to an organised community (like PD) and are not positioned as subjects (like UCD). Co-design can hold political discussions as a purpose-led approach without losing the concreteness of designerly thinking, knowing, and acting. As per co-designs robustness and adaptability, the process responds to trends in the theory of design, expanding the application of the approach to complex systems and strategic thinking. Experiments in foresight design (Voros, 2006, 2003) and transition design (Irwin et al., 2015) are current examples of the use of designerly systemic thinking to anticipate and interfere in future states of sociotechnical systems (van der Bijl-Brouwer et al., 2021).

In this section, I demonstrated that the forms of inclusion in technology design and the industry's practices have varied. Even if the conceptualisation of a theory of design seems to mirror such developments, the emergence of Participatory Design, User-Centred Design, and Co-Design was mostly led by practitioners. From the rationality that freed design from the "genius masters" to the recipe-like methods to stir up innovation in adjacent fields, design practice has matured. The practice can now be open to other forms of expertise, much more accessible for the external, non-trained public, understanding that anyone can *design*.

2.3. Co-design and Smart Homes

As mentioned previously, the three main forms of including people affected by technology in its development process don't follow a hierarchical order. They coexist, overlap, and complement each other. However, co-design's openness to discuss and challenge power dynamics, alongside the partnership established with the people participating, grants

the method a transformative character. In doing so, co-design seems to be the most promising form of inclusion to encourage more responsibility and justice around the development and use of smart home technologies.

2.3.1. Previous Co-Design of SHT

With a simple search in academic literature repositories, it is possible to see that many studies have tried to include external publics affected by SHTs in their research procedures. Studies retrieved (n=644) refer to inclusion using vocabularies such as "co-design", "participatory design", "user-centred design", "human-centred design", "life-centred design", "design justice", "responsible innovation", all concerning "smart home technology" or "smart technology". Most of them, however, still dialogue with a product-focused, technofix discourse without facilitating negotiation between dissonant *imaginaires*, reinforcing the existing hierarchies between passive "users" and "powerful" tech developers.

From the initial search, 27 studies published between 2004 and 2024 [Appendix A] were selected based on the explicit declaration of using co-design and presenting some of the general characteristics of the process (Subsection 2.2.2). There's a general intention among them to include the public external to the traditional development of SHTs, and in rare cases, it's possible to see non-explicit attempts to focus on discussing the problems and issues within the technology (instead of developing a solution in the form of a new product). By reviewing the studies' inclusion strategies, co-design methods, and outcome focuses, it is possible to cluster them into three main groups [Table 2.1]: a first group of studies with weak inclusion strategies and methods still focused on retrieving information from participants to enhance new or existing smart technologies. A second group of studies undermined their inclusion strategies by using traditional, well-established research methods, which reinforce hierarchies and the solutionist use of generating knowledge. The third group of studies is the closest to co-design transformative potential, but only some of them deliberatively challenge the unfair dominant power dynamics encompassed by SHT development and use.

	Analysed Criteria			
Summary	**Inclusion**	**Process**	**Focus**	**Examples**
Non-democratic co-design processes, with solutionism being masked by a weak inclusion strategy that is still focused in retrieving information to enhance new or existing smart technologies	✓			*(De Ruyck et al., 2019; Ngankam et al., 2023; Pradhan et al., 2020; Reisinger et al., 2023; Yao et al., 2019b) among others.*
Inclusion strategies undermined due to traditional hierarchical participation methods, and the solutionist use of generate knowledge	✓	✓		*(Cockbill et al., 2020; Decorme et al., 2014; Fitton et al., 2018; Garg and Cui, 2022; Hwang et al., 2012) among others.*
Inclusion of vulnerable social groups, through open co-design methods, with outcomes broadly targeting benefits to participants	✓	✓	✓	*(Chidziwisano and Jalakasi, 2023; Ghajargar et al., 2017; Kozubaev et al., 2019; Raju et al., 2021; Renström, 2019)*

Table 2.1 - Previous smart home technologies co-design studies from 2004 to 2024.

Furthermore, the analysis of previous co-design studies has shown three main trends: (a) most studies still lack diversity in their inclusion strategies, preventing contact between different sample groups; (b) without a strong theoretical background, they employ short-term and top-down methods to extract information from participants placed as research subjects; and finally, (c) a great part of the studies is focused in the improvement of smart products or the generation of new features and solutions to the market.

Designing with Diverse Imaginaires

An overview of previous SHT co-design studies reveals a **difficulty in including diverse *imaginaires***. The great majority of the studies have been performed or are associated with institutions from wealthy, highly industrialised countries, mostly in the Global North. Even if the study highlights the need to broaden perspectives and include underrepresented groups affected by SHT, there's a clear dependency on the dichotomy of users-industry, revealing associations with UCD practices. Even with participants belonging to different demographics, they were generalised by their common characteristic of being "users". Additionally, when a different sample presenting a specific profile was included (e.g., technology experts, professionals, etc.), **samples were not merged** in the same working groups (Chalhoub et al., 2024; Raju et al., 2021), limiting the overall involvement of underrepresented groups in shaping SHT.

Contrastingly, one of the studies mentioned the aim to integrate users in the research as "equal partners" (Bourazeri and Stumpf, 2018, p. 1). Another study highlighted the aim to "actively and deeply engage" with a vulnerable community in Mumbai, to go beyond interaction forms informed by dominant users' *imaginaires* (Raju et al., 2021, p. 2).

In their attempt to unveil industry or users' needs and expectations from SHTs, studies tend to refer to Kim and Jasanoff's concept of sociotechnical imaginaries (Jasanoff and Kim, 2013, 2009)—or the "collectively held, institutionally stabilised, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology." (Jasanoff, 2015, p. 4) Although valuable in revealing stable, dominant discourses, sociotechnical imaginaries downplay the singular and context-based ways in which people imagine technology (Suchman et al., 2008). In prioritising dominant visions, the use of sociotechnical imaginaries in co-design risks reinforcing the lack of representation of diverse narratives (Pereira and Hargreaves, 2024).

Inclusion that allows for participants to build trust and a common ground for discussions takes time. A constant collaboration in the form of meetings or communication channels is therefore essential for co-design to foster reflection and critical thinking on participants' *imaginaires* of SHT. Many studies suffer from **timeframe constraints**, limiting participants' engagement momentum (Cagiltay et al., 2020; Fitton et al., 2018; Ghajargar et al., 2017; Yao et al., 2019b, 2019a). The research methods of the studies can

also suffer, with little to no time for participants to challenge concepts and definitions by themselves. Researchers have opted for established and efficient data collection and analysis methods often found in solutionist approaches.

Technology-Pushed Design of Solutions

Even when diverse *imaginaires* are included in co-design, a great part of the studies maintains an exploitative **top-down approach** to their participation. In many ways, those are methods established in academic research and can provide trustworthy results. Yet, traditional academia is not necessarily interested in procedures that can transform its hierarchical structures, conceding decision-making power to the public and sharing scientists' leadership. Therefore, such methods risk keeping participants as informants, not co-designers, feedbacking their opinions, preferences, and needs to increase the technology's usability and acceptance. Among the studies explicitly stating their aims and research questions, the focus was either to understand users to **improve products** or to find **new product features and design solutions**. Consequently, such studies ended up reinforcing *imaginaires* of indiscriminate technological progress, igniting the technofix in solutionism. This absence of collaborative engagement with participants can hinder the potential of transformative insights and shared knowledge that could emerge from a co-design.

In contrast with the dominant top-down approaches, Kozubaev et al. (Kozubaev et al., 2019) describe the initiatives of a social housing organisation called Atlanta Housing in reaching out to researchers to better understand the potential of SHT for their community. In this case, the members of the community are the most interested participants in the study, and they are not only informants reacting to devices. Other studies have presented insights that go beyond the techno-fix. For instance, by creating knowledge on smart home gender dynamics (Chidziwisano and Jalakasi, 2023), understanding the relationship of older adults with SHT (Ghorayeb et al., 2023; Pradhan et al., 2020), and depicting users' and indirect users' privacy perceptions (Yao et al., 2019b, 2019a). Working with the potential long-term assessments of living lab householders, Renström (2019) uses co-design to foresee domestic roles emerging from using smart home technologies.

Staying with the troubles of SHT doesn't mean not designing technology. It means making the technology work around the complex, wicked problems instead of trying to solve them. For instance, Raju et al. (2021) engage a vulnerable community from an informal territory to co-design ways in which their communication means could improve. Instead of looking for the most advanced SHTs, researchers looked for the opportunities available in the community, partnering with local artists and artisans to craft prototypes based on descriptions produced by the community.

Another aspect of solutionism might be present in the **lack of robust theoretical frameworks** in the studies. They often rely on their methodological choices to frame and justify the research, with a focus on usability, applicability, and feasibility. Such an instrumental approach can make it difficult to engage with existing literature, **overlooking broader systemic issues** or leaving essential questions of power and responsibility unaddressed. Contrastingly, some studies present conceptual frameworks around empathy (Ghajargar et al., 2017), domestication and adoption (Kozubaev et al., 2019; Reisinger et al., 2023), women's rights and patriarchy (Chidziwisano and Jalakasi, 2023), and design heuristics (Chalhoub et al., 2024).

In summary, previous co-design studies associated with SHT tend to reproduce sociotechnical power dynamics as the industry's *imaginaire* has been prioritised. That happens because design is used in a rushed way to find solutions, not to further elaborate the dimensions of the problems. They also struggle to involve diverse *imaginaires*. Furthermore, the studies analysed rarely included evaluations of their own methods, which is essential for researchers and participants to understand their ways of doing co-design.

Opportunities for Changing Design Practice

Previous studies' lack of strategic thinking and robust framing of design problems can be associated with results reinforcing the irresponsible ways smart home technologies have been produced and used. Within the climate emergency scenario, there is an urgency for research and innovation to go beyond designing different sustainable artefacts and start meta-designing (Vassão, 2019) more responsible and just co-design practices (Hocking, 2010). The complexity surrounding existing sociotechnical systems creates the opportunity to experiment with alternative design frameworks.

Such experiments are not exclusive to academic research. Practitioners in the context of digital technology innovation have indicated the importance of the messy early stages of a design process, as those are the problem-framing stages [Figure 2.1]. Conceptualised as the "fuzzy front-end" of design, or FFE, the initial exploration of alternatives seems to contribute to the adoption success of new products (Kim and Wilemon, 2002, p. 269). Kim and Wilemon highlight that "critical problems not solved in the FFE, however, can bring about barriers and resistance in the development phase." (2002, p. 271) In providing a rushed solution, there's a risk of creating new problems.

Due to technology-push and solutionism associated with the current co-design of SHTs, the industry does not appear to dedicate sufficient resources to the FFE in the innovation life-cycle. The more extractive and anti-democratic methods in use aim for rapid product development with a profitable margin. As Søndergaard questions: can we deal with such

uncertainties and complexity in today's crisis using established methodologies rooted in user-friendliness or efficiency?" (2020) The answer might be in troubling traditional methodologies instead of following them.

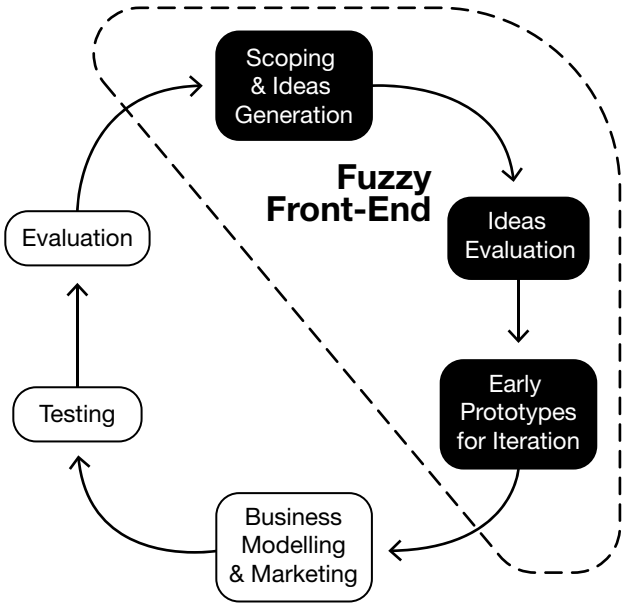


Figure 2.1 - Diagram contextualising the fuzzy front-end in innovation life-cycle, adapted from Tate et al. (2018).

With a focus on the digital services and technology market, innovation design scholars have claimed that there is an opportunity to transform the technology industry by promoting better management of design's FFE (Kim and Wilemon, 2002; Tate et al., 2018). With additional resources and time, a robust FFE is thought to generate successful products. More than merely extending the FFE followed by conventional technology development methodologies, I argue that the true opportunity lies in the initial uncertainties and ambiguities of design, which can be strategically introduced throughout a co-design process to intentionally disrupt irresponsible and unjust sociotechnical systems that currently inform technology design.

2.4. Conceptual Framework and Research Questions

This section will propose a conceptual framework for a co-design study capable of diversifying the inclusion of alternative *imaginaires* around smart home technologies without recurring to solutionist methodologies. At the end, the research questions emerging from such a framework will be introduced.

2.4.1. Co-Imagining Ways of Staying with SHT

As mentioned before, design practices have been commodified and instrumentalised through the technofix in solutionism discourse, reinforcing existing unjust, unsustainable, and irresponsible social structures. Still, the designerly ways of knowing, thinking, and acting are not limited to their industrial inheritance. I argue that their effectiveness in innovation can contribute to enacting transformative futures. However, instead of prioritising the search for a suitable technological solution, design should be seen through the perspective of the problem. For this conceptual framework, designerly ways of understanding, coping with, and caring for complex problems surrounding SHT development and use are ways of staying with their troubles.

One of the crucial design practices described by Nigel Cross is the one of problem-solving (1982). For the author, designers have a particular way of solving given problems (Subsection 2.2.2). Designers "work with a model called problem-solution co-evolution" (Dorst and Cross, 2001, p. 11): sooner rather than later, designers develop temporary solutions, testing them against the problem, allowing one to iteratively understand the dimensions of the ill-defined and open problems they're dealing with. The "problem-solution co-evolution" model is described by Dorst and Cross as containing a problem space (PS) dimension and a solution space (SS) dimension [Figure 2.2]. Designers recognise a "partial structure of the problem" using their existing knowledge, assumptions, and *imaginaires* of it, which then informs the "partial structuring" of a temporary solution: "They transfer the developed partial solution structure back into the PS, and again consider implications and extend the structuring of the PS." (Dorst and Cross, 2001, p. 12)

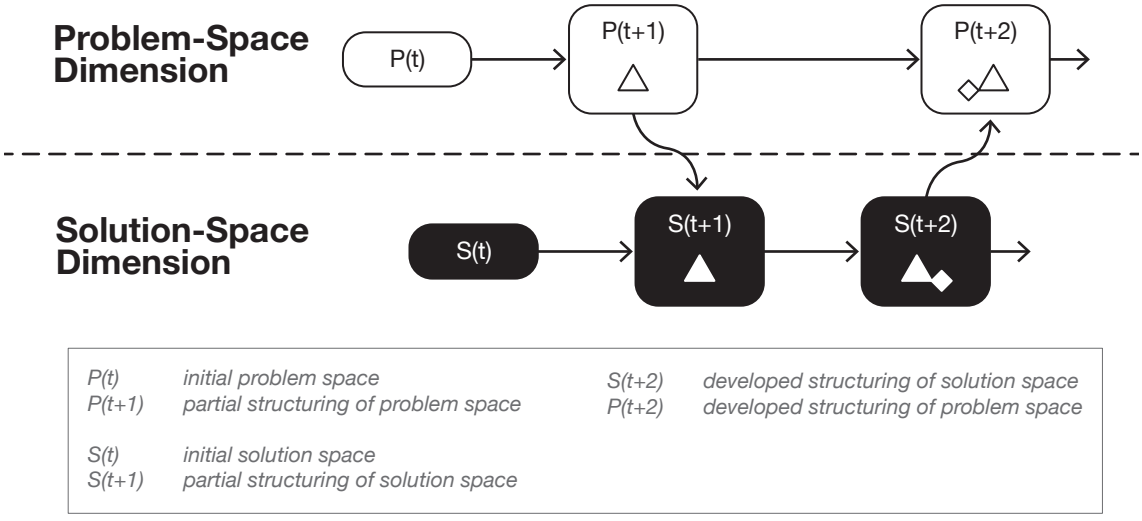


Figure 2.2 - Problem-solution co-evolution diagram adapted from (Dorst and Cross, 2001, p. 12).

Designers deliberatively suspend their lack of information about a problem to cope with its complexity, relying on their experience, existing knowledge, assumptions, and *imaginaires* to formulate a partial solution. Therefore, temporary solutions in a design process present a speculative nature of what a suitable answer *could* be—but not necessarily *is*. They are tentative approximations to an opaque, complex problem. The speculative nature of the designerly ways of understanding, coping, and taking care of wicked problems is essential to developing a non-solutionist co-design practice that promotes an expansion of understandings and perspectives surrounding SHTs. As not every wicked problem calls for a reductionist technical solution, a terminology change seems adequate. For their complex, ill-defined, unexpected character, in the following chapters, such events, disputes, and prejudices will be referred to as Haraway's troubles (2016).

As a designerly way of staying with the trouble, the contribution of speculative design should be different from that of a traditional design process. The latter focuses on satisfying an initial briefing with a suitable solution, while speculative design intends to widen the scope of possibilities, challenge existing norms, and scaffold alternative *imaginaires* (Tharp and Tharp, 2022). Participants of a co-design that makes a deliberative use of such speculative traits of designerly ways of knowing can better understand the troubles associated with the technology, developing the critical reflection necessary for discussing SHT's governance and regulation.

Speculative design belongs to a discursive design agenda where designed artefacts are "understood to be deliberately embedded with, positioned as, or engendering discourse" to encourage reflection and debate (Tharp and Tharp, 2022, p. 51). Speculative design has many forms and has been applied in different contexts "as thought experiments—constructions, crafted from ideas expressed through design—that help us think about difficult issues." (Dunne and Raby, 2013, p. 80) For instance, the "critical making" of objects described by Ratto (2011) is not focused on displaying objects to an audience but rather an "act of creation, fabrication, and contextualisation" of the discussions (Galloway and Caudwell, 2018, p. 5).

In her book, Haraway had already indicated speculative fabulations, science fiction, and other forms of creatively inventing alternative realities as forms of avoiding creating solutionist techno-utopias, risking even more complex organisations of the existing troubles (2016). Applying Haraway's call through speculative design, Søndergaard argues that "the action of troubling become ways of reflecting on alternative design approaches that engage with uncertainties and complexities of lived experiences." (2020, p. 3)

> "Our task is to make trouble. To stir up potent response to devastating events, as well as to settle troubled waters and rebuild quiet places." (Haraway, 2016, p. 1)

Speculative design has allowed critical reflection on smart technologies before. In the project 'Intimate Futures' (2020), Søndergaard wanted to trouble the assumption that women's sexual health and intimacy needed to be fixed with a design solution. The author then describes staying with the trouble as a "design program" contrasting with the solutionism practised by the tech industry: instead of looking for solutions to a poorly framed (and maybe inexistent) "problem", their focus is on the "problem" and the speculative ways to stay with it critically. One of Søndergaard's experiments using the design program produced 'AYA' (2020), a design fiction project that stays with the trouble of gender stereotypes in SHT. Rather than presenting a female voice assistant as an obedient and passive voice, AYA confronts "sexually suggestive or aggressive commands", pushing back in a humorous, sassy, and, sometimes, threatening way (Hargreaves and Pereira, 2023, p. 60) Another example of staying with the trouble of problematic gender relations in SHT is 'DICK': the first "all-male" voice assistant (Knowit, n.d.). The project intends to raise awareness using provocative harmful behaviour in DICK's unique features, including "being easily offended, lazy, selfish, self-pitying, emotionally needy, creepy, sexist, arrogant and occasionally forgetting to listen." (Hargreaves and Pereira, 2023, p. 60)

Nudging critical reflections about smart security technologies, 'The Staredown Toolkit' stays with the trouble of levels of surveillance that householders allow in their everyday lives (Shin, 2022). Using colourful cases to reposition smart security cameras and sensors as playful decoration "rather than sinister objects in the home." (Hargreaves and Pereira, 2023, p. 60) They also speculate on an alternative way of staying with extensive archives of surveillance footage. Shin proposes to "stare back" at surveillance using an archive app to "encourage reflection on people's not-so-adventurous or dangerous everyday practices and, therefore, raise questions about the ubiquity and necessity of surveillance footage in contemporary society." (Hargreaves and Pereira, 2023, p. 60)

Staying with the trouble of the consumerist nature of energy feedback in the home, the speculative project 'Energy Babble' (Boucher et al., 2018; Gaver et al., 2015) is an automated talkative radio communicator capable of sharing energy consumption information alongside insights about the UK energy distribution grid and energy policy. Instead of reinforcing intense energy consumption behaviour, Energy Babble intended to raise critical awareness over energy demands, building a community of "energy citizens" rather than "energy consumers" (Gaver et al., 2015; Hargreaves and Pereira, 2023).

Speculative design, however, has limitations. For instance, it is often characterised as a privilege of a few. The construction of the previous examples of speculative SHTs happened in academic and expert design contexts. The practice of imagining alternative social, economic, and environmental systems can sometimes be restricted to individuals who can spare time apart from the modern burdens of everyday life—e.g., work, finance, consumption, care responsibilities, social media, etc. Yet, as per its ontological nature, the phenomenon of imagination cannot be restrained (Bachelard, 1971). Despite being

exposed to restrictive and vulnerable contexts, individuals can experience imaginative drifts, even if in the form of personal resistance towards a desirable, more bearable reality. If made accessible and collective, speculative design can then be expanded, promoting critical reflection over the psychological, sociological, and ideological aspects of *imaginaires* (Tharp and Tharp, 2022).

There's a need to infrastructure and nurture imaginations beyond dominant groups. In the context of this research, alternative, critical, and speculative *imaginaires* must be promoted not only in technology development, but in people being affected directly or indirectly by smart home technologies. I suggest doing this by including underrepresented groups in collective speculation to find ways to staying with the troubles of SHT.

Co-design can help disturb, and thus, diversify, current *imaginaires* of SHT, cause them to change, and, with specific critical input, make them more responsible and just. The urgency and magnitude of the sociotechnical transitions triggered by the climate emergency might also be a moment to "question more fundamental assumptions regarding the way our society works, and whether elements should be structured entirely differently." (Nyborg and Røpke, 2011, p. 1858) This research aims to collectively use the discursive designerly ways of knowing, thinking, and acting to challenge the industry's SHT *imaginaire*. Organising a co-design process that supports the diversity of co-existent, competing SHT *imaginaires*, constantly negotiating and interacting with each other, affecting each other, and modifying each other—instead of prioritising the generation of a fixed technical solution as the representation of a unidimensional understanding of the trouble and the technology.

2.4.2. Emerging Research Questions

This chapter elaborated on the many ways smart homes can be imagined and how each representation of the technology carries social values systems that can be enacted in its development and use. The social, economic, and environmental consequences of the mass adoption of SHT are still opaque to the *imaginaries* of people designing or consuming the technology. At the same time, previous co-design studies struggled to incorporate more diverse social groups capable of sharing alternative *imaginaires*. It's essential to frame the visions, representations, and discourses participating in SHT development if the design of smart home technology and the technology itself need to become more responsible and just. Furthermore, for different people to work together in a co-design process, being aware of each other's perspectives and references can build empathy.

The first research question I will answer through this thesis emerges from the role played by individuals' subjectivities in co-producing SHTs:

> **(RQ1) What are the dominant *imaginaires* shaping the development and use of smart home technologies?**

In answering such a question, it's possible to have a holistic visualisation of tensions, oppositions, contestations, and resistances (i.e., troubles) between dominant *imaginaries* animating the needs and expectations of developers, designers, adopters, and non-adopters.

Understanding the risks associated with approaching smart technology troubles with solutionist, commercial design practices, this literature review has demonstrated that SHT design should focus on better elaborating the origins, actors, and impacts of the troubles surrounding the technology. Having diverse *imaginaires* staying with SHT's troubles through a speculative co-design can contribute to critical reflections on the technology.

The second research question I will approach in this work comes from the discursive design agenda and the designerly ways in which it can be applied through a speculative, non-solutionist co-design. From that, I pose:

> **(RQ2) How can co-design methods affect the *imaginaires* behind smart home technologies?**

This question will help to address the role of co-design as a way to stay with the troubles surrounding SHTs, instead of solving problems. As such, a "trouble-focused" co-design can contribute to participants' empowerment journey over SHT.

Incorporating more diverse *imaginaires* in a speculative co-design of SHT seeks to enact responsibility and social justice in an often inequitable and technocratic field. As it was possible to assess from previous SHT co-design studies, the inclusion of external publics is not enough to guarantee a transformative design process. More attention should be brought to the social groups involved, the methodologies employed, and the spaces occupied by the process.

The third and last question emerges with the intention of evaluating the needs and characteristics of a more responsible and just co-design of smart technology:

> **(RQ3) What are the implications of co-design for creating more responsible and just smart home technologies?**

As responsibility frameworks and inclusion in technology design usually lack social justice discussions, this question aims to address the latent need for co-design to be positioned within broader, structural, social transformations.

The methodological procedures to approach the above-mentioned research questions will be introduced and detailed in the following Chapter 3. Then, through the analysis of the data collected in this research's co-design, the research insights presented by Chapter 4-6 elaborate and frame the answers that will contribute to a more responsible and just ways of developing, adopting, and staying with smart home technologies.

3. Methodology

Following the previous literature review, this chapter will delineate the methodology applied to collect and analyse the data pertinent for answering the research questions. This research's philosophy is characterised by co-design and the constructivist theories behind it. In so doing, throughout the study, I have acknowledged that social values, belief systems, and *imaginaires* can be made durable by dominant social groups, conditioning the development of digital technology—which, in the case of Western modern society, have been following solutionism and positivist values, supported by individualism, capitalism, neo-liberalism, and neo-colonialism. Thus, considering digital technology as socially constructed, I suggest here a collective reconstruction of it, with alternative social values, belief systems, and *imaginaires* that allow a more responsible and just development and use of SHTs.

One possible way to evidence the subjectivities currently embodied in SHTs is by analysing the *imaginaires* animating the technologies. However, *imaginaires* are an elusive and opaque phenomenon and, as such, often inaccessible for direct scrutiny or deductive inferencing from science or rational design paradigms. As mentioned by Hocking (2010), designerly ways of knowing have the potential to engage with complex and dynamic circumstances such as the expression of *imaginaires*.

Following the role of visual representation as a designerly way of knowing (Cross, 1982), and the visual constitution of the *imaginaire* (Wunenburger, 2020), research over individuals' subjectivities requires means of expression for them to externalise and ground their imagination. An individual's excerpt of *imaginaire* can be seen as a still, a fixed fragment of a dynamic phenomenon, analysable in the face of existing external representations and discourses through an interpretative approach. Therefore, this co-design research has relied on anthropological and phenomenological theories in order to access the symbolic process of giving meanings and forms to SHTs.

Non-hierarchical participation was prioritised to open space for the historically neglected domestic and home experiences. On the way to formulate research insights, the methods employed here (and described next) have progressively transformed the relationship between people participating and smart technologies. There was an intention for participants to experience an atelier or studio-like ambience, supporting collaborations through critical making (Ratto, 2011). The co-design study agitated and ignited imaginations, allowing the discomfort of openly discussing complexities between individuals' and their technologies, political discourses and socio environmental impacts, and any other troubles surrounding participants perceptions of SHTs.

3.1. Research Design

This thesis emerges from a frustration with unfair hierarchies that have been framing design practices. Thus, grounded on my professional training as an architect and experiences as a design facilitator, I take a normative standpoint to exemplify forms in which co-design can better support transformative and structural social change.

As part of the GECKO Project (https://gecko-project.eu/), a Marie Skłodowska-Curie Innovative Training Network (H2020, Grant Agreement No 955422), this research is among 15 projects exploring the use of accountable, responsible, and transparent AI technologies to address environmental needs and the European green transition. The GECKO consortium comprises nine hosting institutions and another nine academic and industrial partners, providing an interdisciplinary and intersectoral infrastructure to support research development.

This research relied on a mixed design to establish a one-year longitudinal participatory study enacting the co-design philosophy. The study also presents cross-sectional and comparative aspects (Clark et al., 2021) due to the analysis of the three distinct samples ranging from professionals developing SHTs, adopters of the technology, and non-adopters (more of that in Section 3.2). The diverse characteristics present in each sample group were essential for fostering contrasting discussions that occasionally required me to step back from the role of lead researcher.

It is important to acknowledge the multiple roles I assumed throughout this study. The overall intention was to avoid unjustified interventions in participants' activities. As mentioned previously, participants were encouraged to frame concepts and make design decisions without my interference. In this capacity, I acted as an observer of their co-design process. However, considering my design expertise, I occasionally offered assistance in representing or crafting activities; in this sense, I also embraced a co-designer role.

My flexibility as an active researcher assuming alternative roles in this participatory design study has influenced the way participants engaged with the research, along with the references and examples provided throughout this study. I took part in group

discussions, extending my contributions as a partner in the co-design process. When such discussions occurred, rather than offering scientific or academic information, I deliberately shared insights based on my everyday life as a Global South, LGBTQIA+, cis-gender man.

Inclusion is a fundamental aspect of Responsible Research and Innovation (RRI) frameworks, and, as such, it was essential for this co-design study to follow ethical practices in order to respect participant's autonomy and protect any sensitive information regarding their participation.[3] It has been imperative that people declare their informed consent to take part in the research study [Appendix B, Section 1-2], contributing to position them as partners, "co-designers", and not research subjects.

The research design was deliberatively responsive to the context and needs of participants—instead of delineating a fixed and strict form of participation, usually found in anti-democratic and exploitative inclusion practices. For instance, even with the general theme of discussion and research questions being framed in advance (e.g., smart home technologies), participants were expected to negotiate their own focus and priorities over the subject. There was an overall intention to avoid a deterministic data collection and analysis, distancing this co-design study from solutionism "in order to maintain a fluid, dynamic nature and to maximise the ability for working within messy, complex systems" and unexpected circumstances (Hocking, 2010, p. 247)—or, i.e., to practice staying with the trouble (Haraway, 2016).

Following the characteristics of co-design mentioned in the previous chapter (Subsection 2.2.2), this research has used design methods to instrumentalise both data collection and analysis—i.e., it can be said that the research was conducted *through* a design process [Figure 3.1] (Faste and Faste, 2012). As an interventionist type of research, my experiences as a professional designer have unavoidably impacted the creative and playful ways in which data was collected and analysed. Instead of developing a standard qualitative research study that would later inform the design of technology ["Design-through-Research" in Figure 3.1] or having previously designed technology as a research subject ["Research-on-Design" in Figure 3.1), new research insights have been collectively generated through the design process itself—or, in Cross's terms (1982), through designerly ways of knowing and researching.

Research-through-Design (RtD) is a multimethod, qualitative research strategy, and in the case of the current study, it has combined participatory research methods (e.g., workshops, focus groups, etc.), and art research methods (e.g., assemblage, image board, etc.), to design research methods (e.g., sketching, speculative design, scenarios, etc.). To enable the organic emergence of insights from participants, the activities proposed by

3. This research study has received ethical clearance (ETH2223-0892) on 22nd November 2022, from the University of East Anglia's SCI S-REC (Faculty of Science Research Ethics Subcommittee), in compliance with the Data Protection Act 2018 (DPA 2018) and UK General Data Protection Regulation (UK GDPR), and the University of East Anglia's Research Data Management Policy.

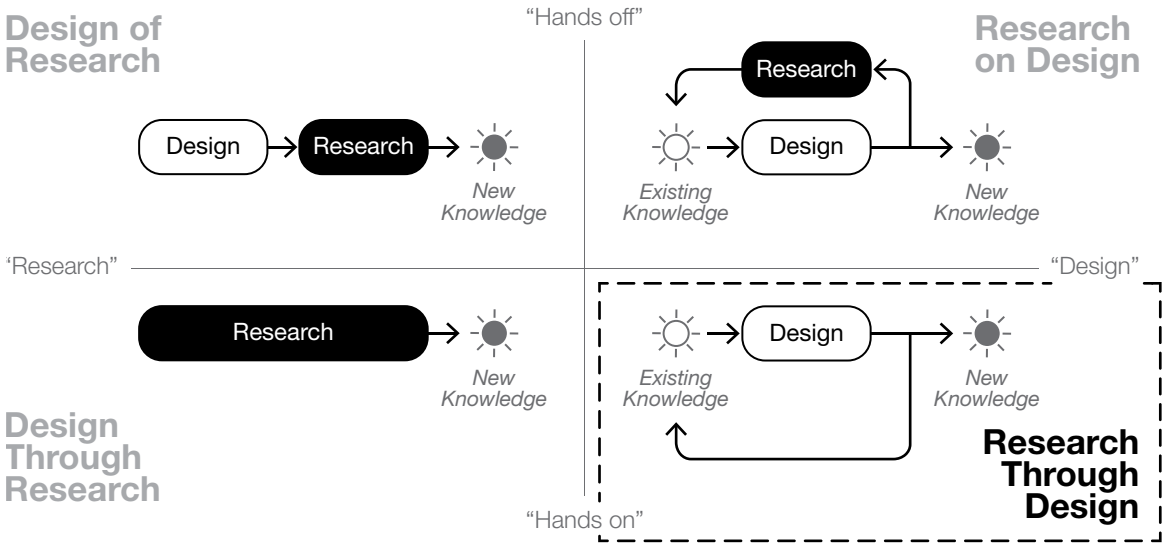


Figure 3.1 - Diagram adapted from Faste and Faste, 2012, p. 6., demonstrating the different quadrants of design research through the order of design practices in relation to the production of new knowledge.

this study considered the various ways in which they felt comfortable co-designing. To prevent participants from 'hiding in abstractions', reflection was encouraged through crafting physical artefacts (Sanders and Stappers, 2012, p. 70). The potential of such 'making' activities lies in uncovering participants' tacit and latent knowledge (Sanders and Stappers, 2012). The playfulness of such creative methods has provided an engaging experience for participants while remaining accessible to a "range of skills, education, and confidence" through its visual and tactile nature (Hocking, 2010, p. 247).

The dynamic posture I assumed as a researcher and co-designer enabled "reflections-in-action." (Schön, 1986) Insights emerged from within the data collection workshops, focus groups, and interviews. These early reflections were crucial in framing the subsequent phases of data collection and guiding the initial stages of data analysis (more about data analysis in Section 3.4).

Nevertheless, RtD studies tend to lack verifiability and transparency due to the elusive and designerly nature of their methods (Prochner and Godin, 2022; Zimmerman et al., 2010). To guarantee research rigour and reproducibility, the data collection and analysis process have been detailed in this chapter, and the qualitative datasets it generates have been thoroughly documented, organised, anonymised, and are available at Zenodo[4] (Open repository for EU-funded research outputs from Horizon Europe). The datasets were made open access under Creative Commons Attribution 4.0 International (CC BY

4. Datasets relative to each research phase can be found in the following links. Phase 1: https://doi.org/10.5281/zenodo.10912781; Phase 2: https://doi.org/10.5281/zenodo.10913030; Phase 3: https://doi.org/10.5281/zenodo.10913103; Phase 4: https://doi.org/10.5281/zenodo.10913113.

4.0) licensing, allowing participants and third parties to access, mine, exploit, reproduce and disseminate the data and metadata associated with the research for non-commercial uses.

Following the literature on both design theory and co-design (Cross, 2023; Iversen et al., 2012; Kolko, 2018; Steen, 2013), the data collection and analysis procedures were organised in a research design spread over four phases [Figure 3.2]. This research design then resonates a co-design process with the emergence of social values, development of such values, grounding of values, and realisation of values (Subsection 2.2.2). Such longitudinal engagement through design provided the establishment of deeper connections with participants in meetings, as well as the time for me to perform preliminary analysis [Figure 3.2], so the study could be responsive to results collected (Hocking, 2010) and prepare adaptations on subsequent phases if needed.

Starting with Phase 1 [Figure 3.2], where participants **explored** representations of their *imaginaire*, allowing for a comparison between samples' *imaginaires* that revealed troubles in how different groups expect SHTs to be. This phase is relative to the emergence of participants' values, therefore the methods employed here allowed for the open emergence of participants' insights and representations. Once exposed in visual representations, diverse *imaginaires* have been acknowledged by other participants in an empathetic and open conversation.

In Phase 2 [Figure 3.2], participants co-designed more responsible and just ways of staying with the troubles emerging from Phase 1, **describing** speculative and provocative interventions in how SHTs are developed and used today. With curiosity and negotiation, participants have stayed with SHTs' troubles, defining which aspects of smart technology must be prioritized and creatively grounded through speculative design. In Phase 3 [Figure 3.2], participants reflected on what were the potentials and pitfalls of their co-designed interventions, **prescribing** how those could be enacted and who would need to be involved for it to happen. Both Phase 2 and 3 are relative to the development and grounding of participants' values, therefore using methods and tools that would create some form of reference or support in the troubled journey towards speculating on smart technologies. With more structure than in Phase 1, these methods allowed for a deeper exploration of metaphors, feelings, and dreams (Sanders and Stappers, 2012).

In a final Phase 4 [Figure 3.2], participants have **evaluated** the study using existing frameworks of co-design, understanding its contributions and how it can be improved so co-design can achieve its transformative potential. This last phase is connected to the realisation of the values enacted throughout the co-design process.

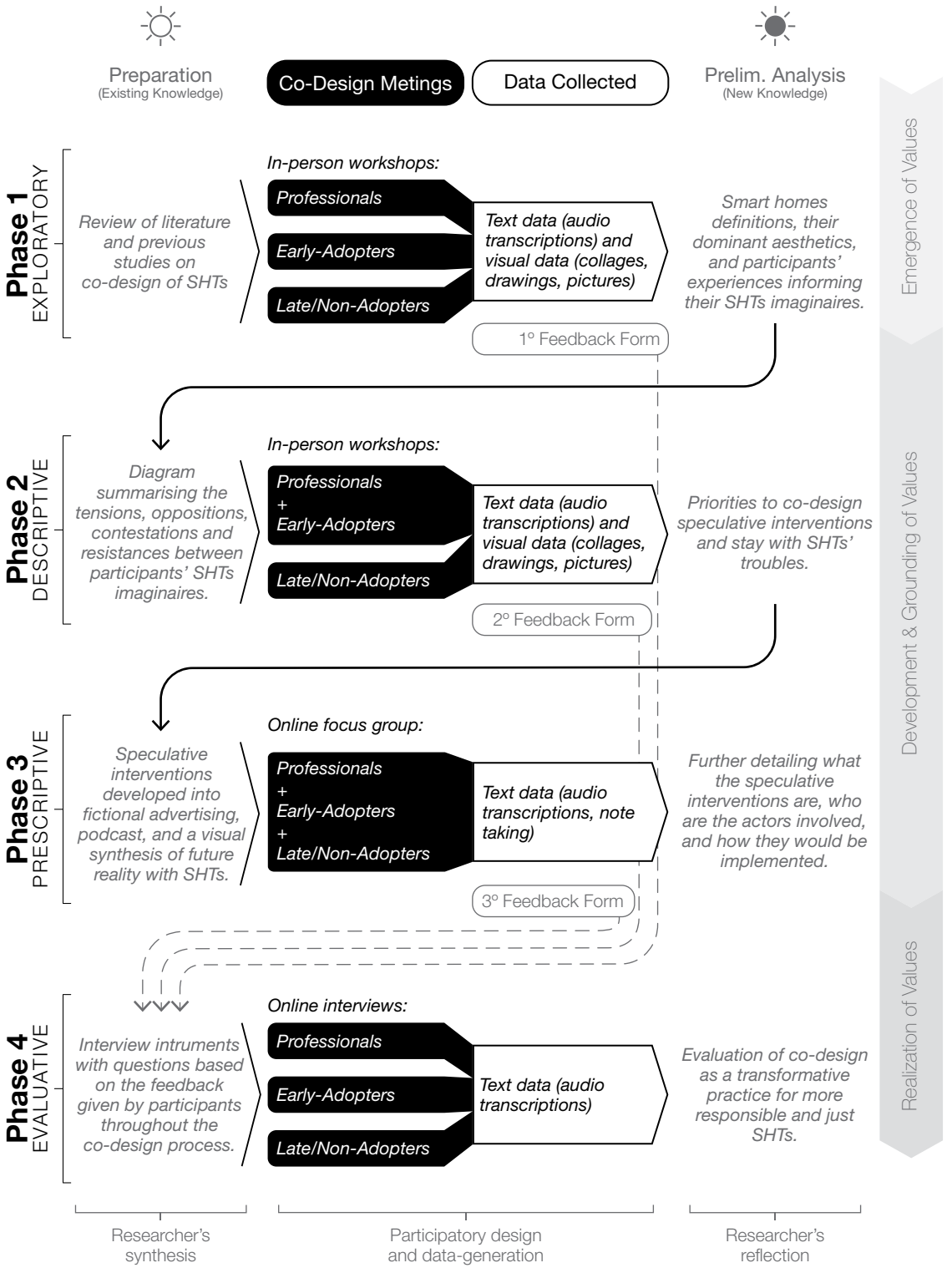


Figure 3.2 - Overview of data collection flow from Phase 1 to Phase 4, showing active participation and synthesis moments. Each phase is also corresponding with the co-design general stages.

3.2. Sample, Recruitment, and Compensation

Considering the participatory nature of the research design, sampling participant cohorts relevant to the study of SHTs was essential. A theoretical sampling strategy (Clark et al., 2021) informed by literature insights was used. The profile of samples took into consideration the lack of diversity in current technology design, as well as the fact that previous co-design studies tended to focus on single sample groups—which doesn't provide much margin for comparative research.

For its well-known terminology, Roger's technology adoption profiles (2003) were used as a tool to facilitate the framing of potential sample groups. Finally, three stratified purposive sample groups were defined according to their experience with smart home technologies: one group of "innovators" (Rogers, 2003), or participants interested and trained to professionally develop smart technologies, capable of coping with the uncertainties associated with emerging technology, and playing a leading role in disseminating SHTs. A second group is represented by participants already adopting SHTs, as "early adopters" or "early-majority" (Rogers, 2003), composed of people retaining knowledge about the technology from using it and trusting that the technology can benefit their everyday lives. The third and last group represented participants reluctant to adopt SHTs, being the "late-majority", "laggards" (Rogers, 2003), or non-adopters; they are sceptical about adopting new devices and prefer to maintain a more traditional everyday life. The recruitment process was not randomised but rather opportunistic, making use of the existing interdisciplinary and intersectoral network of partners in the GECKO project. The Energy Systems Catapult (ESC)[5] and the iDODDLE project[6] were key partners of this research, as they already had an established panels of participants.

For the sample presenting an innovator's profile, the aim was to recruit professionals directly impacting the development of smart home technologies. This group will be referred to as **Professionals (P)**. The recruitment of Professionals happened during my 4-months industrial secondment at the GECKO partner Energy Systems Catapult (ESC) in Birmingham. Professionals inside ESC were directly contacted through an internal newsletter [Appendix B, Section 3]. In total, seven professionals participated in the study [Table 3.1], all over 20 years old, predominantly white-European cis-gender

5. The Energy Systems Catapult is an advice and consultancy company focused on accelerating the energy transition in the UK. The company is based in Birmingham, and it's part of the UKRI Catapult Network of research and development facilities. More information can be found in the following link: https://es.catapult.org.uk/

6. iDODDLE is a four-year research project funded by the European Research Council (ERC-No 101003083). This partner project aims to help develop a new thematic and inter-disciplinary science of digitalised daily life in support of action on climate change. More information can be found in the following link: https://idoddle.org/

females (n=4) and males (n=3), residing in the Birmingham area (West Midlands, UK), with a higher education degree or equivalent, and in a permanent work position at ESC accelerating the energy transition through smart technologies. They had diverse specialisms, including design, engineering, marketing, and user research. The relevance and novelty of the sample lie in their direct experience in developing and trialling innovative research methods like living labs and engagement workshops to generate inclusive net zero energy transitions.

The sample with early adopters and the early majority has been represented by people generally interested in technology—especially in SHTs—and people already using them in their homes. This group will be referred to as **Early-Adopters (A)**. The recruitment of Early-Adopters also relied on the GECKO project's network of partners. At the end of my industrial secondment at ESC, I was able to recruit participants from their existing panel of consumers engaged in Catapult's Living Lab program. In such panel of consumers, people are already testing smart energy technologies, rendering them as early-adopters of SHTs. The study was advertised in the Living Lab newsletter, and people interested in participating could get in touch via telephone or e-mail [Appendix B, Section 4]. In total, seven Early-Adopters participated in the study [Table 3.1], all over 20 years old, primarily white-British with one Southeast-Asian person, cis-gender females (n=2) and males (n=5), residing in the Birmingham area (West Midlands, UK), with diverse educational levels and occupations or retirement schemes.

The third sample group encompassing late-majority of adopters and laggards represented people reluctant to use technology in general, waiting until the real benefits and risks associated with SHTs are well known before adopting it—or not adopt it at all. This group will be referred to as **Late/Non-Adopters (N)**. The recruitment of Late/Non-Adopters was conducted in partnership with another of GECKO's partners: the iDODDLE project. I was able to recruit participants from their recently stablished living lab cohort in Oxford. As iDODDLE had not yet kickstarted their activities back then, the Late/Non-Adopters recruited haven't had any discussions over smart technologies before this research workshops. This characteristic was essential for a sample of participants with a current low engagement with SHTs. One of iDODDLE's periodical communications advertised this study in a short survey with a comic strip about house automation [Appendix B, Section 5, Groups (i) iDODDLE Mini Mission & (ii) Online Consent Form]. Those interested in taking part could get in touch via telephone or e-mail [Appendix B, Section 5, (iii) Initial Email Contact]. In total, eight Late/Non-Adopters participated in the study [Table 3.1], all over 30 years old, predominantly white-British cis-gender females (n=4) and males (n=4), residing in the Oxford area (Oxfordshire, UK), with diverse educational levels and occupations or retirement schemes.

To preserve participants' anonymity, Professionals will be referred to as P1-P7, Early-Adopters as A1-A7, and Late/Non-Adopters as N1 to N8. Additionally, it's relevant here to acknowledge my active role as researcher, facilitator, and co-designer during the data

collection meetings. However, for reading clarity purposes, in the following chapters, I will deliberately refer to the people involved in the co-design study using the third-person plural (i.e., “they”, “their”, “them”).

Professionals (P)			Early-Adopters (A)		Late/Non-Adopter (N)	
Alias	Gender	Work Position	Alias	Gender	Alias	Gender
P1	Female	*Field Trial Operations Manager*	**A1**	Female	**N1**	Male
P2	Male	*Engineering and Software Support Technician*	**A2**	Male	**N2**	Male
P3	Male	*Engineering and Software Support Technician*	**A3**	Male	**N3**	Female
P4	Female	*Engineering and Software Support Manager*	**A4**	Male	**N4**	Female
P5	Female	*User and Marketing Researcher*	**A5**	Male	**N5**	Male
P6	Female	*User-Researcher and Designer*	**A6**	Male	**N6**	Female
P7	Male	*Simulation and Modelling Engineer*	**A7**	Female	**N7**	Male
					N8	Female

Table 3.1 - Summary table of participants profiles.

As all participants were considered experts in their professional field or everyday life, it was vital that they receive some form of monetary compensation for their time working at the co-design. This decision has been considered part of a more ethical and democratic approach to co-design—as in some forms of exploitative inclusion people will only have access to the benefits of their participation if they purchase a product of service they’ve helped design or improve. On average, £15/hour multi-store gift vouchers were offered as an incentive and compensation for participants’ work time [Appendix B, Section 6]. When necessary, participants were offered an additional £30 covered for travelling to meeting venues.

3.3. Data Collection Methods

This section will detail the methods employed during co-design data collection. Starting with methods to explore smart home *imaginaires* and describe possible interventions to stay with SHTs’ troubles, followed by methods to prescribe how to turn those interventions into reality. At the end, the methods to evaluate the co-design process.

3.3.1. Phase 1: Exploratory Workshops

The first series of workshops characterised the sample groups’ current *imaginaire* around smart homes and their technologies. As this first phase corresponded to the start of our co-design, it was important for the workshop to allow the emergence of participants’ values and subjectivities with activities that permitted empathetic conversations [Figure 3.3]. This in-person workshop [Appendix C, Section 1, (i) Workshop Programme] lasted approximately 2h30min and was performed three times, once with each sample group, from December 2022 to May 2023, in Birmingham and Oxford.

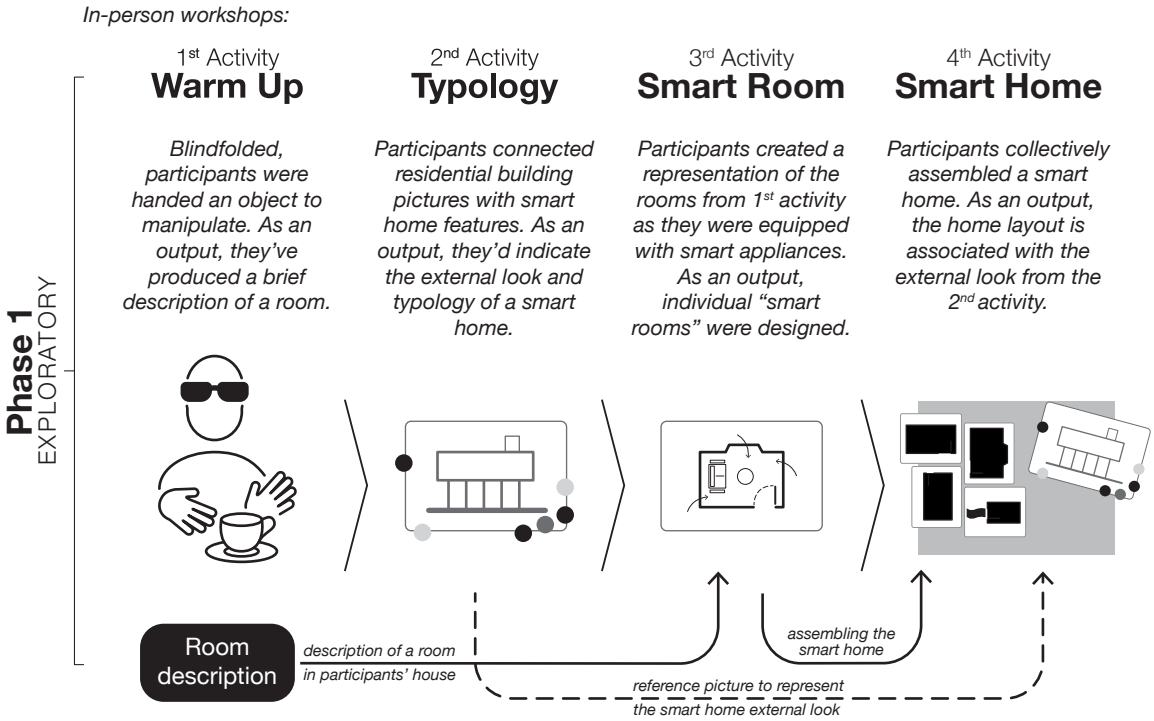


Figure 3.3 - Diagram summarising the flow of activities in Phase 1's exploratory workshops.

Considering that participants presented a diverse range of expertise—and most of them were not formally trained designers—the initial activity of the workshop had to prepare them for the subsequent creation tasks [Figure 3.4]. Inspired by experiments on the correlations between design and psychology performed by the soviet architect and educator Nikolai Ladovksky (Bokov, 2021; Jallageas and Lima, 2023), this workshop

Figure 3.4 - Early-Adopter participants performing the first activity of Phase 1's exploratory workshop blindfolded with opaque paper glasses.

focused on a "whole-body" design practice. Like other scholars in social applied sciences (e.g., Pink, 2015), Ladovksky explored sensory methods to engage all available body senses in design tasks. Instead of privileging their visual apprehension, participants blindfolded themselves while manipulating household objects [Appendix C, Section 1, (ii) Household Objects] and listening to house sounds. In this way, they've expanded their touching and hearing senses before interacting with materials, textures, shapes, and colours that have been presented to them over the course of the workshop. Through this technique, I have deliberatively "disorientated participants into looking at their everyday practices from a different perspective when responding to the visual prompts." (Hocking, 2010, p. 246) The vision obstruction allowed participants to activate their memories as they could only rely on the imagination of the objects they were manipulating and the domestic ambience where they used to find them.

The second activity allowed participants to apply their activated imagination to define the external view of what they believed to be a smart home [Figure 3.5]. In response to prompting questions, participants stuck coloured labels on a series of photos depicting common British residential typologies [Appendix C, Section 1, (i) Workshop Programme] that, in their opinion, visually represent the question's theme. For instance, when asked which residential buildings looked the "safest", participants placed a red sticker on the picture they thought would show the safest residency. It was important for participants to respond using their first impressions, as individuals' reactions to unknown situations rely on their memories of close-enough previous experiences and references—i.e., they replied by accessing their existing domestic and home *imaginaires*. With this activity, it was possible to start framing the aesthetics that each sample group inputs to smart homes.

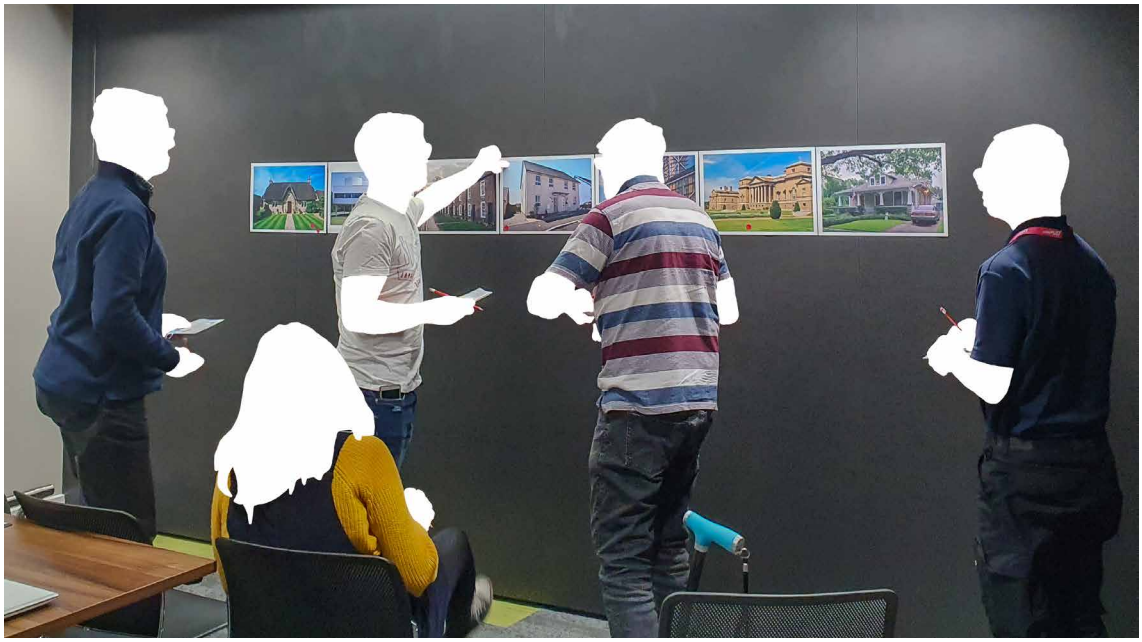


Figure 3.5 - Early-Adopters participants engaging with residential building pictures in the second activity of Phase 1's exploratory workshop.

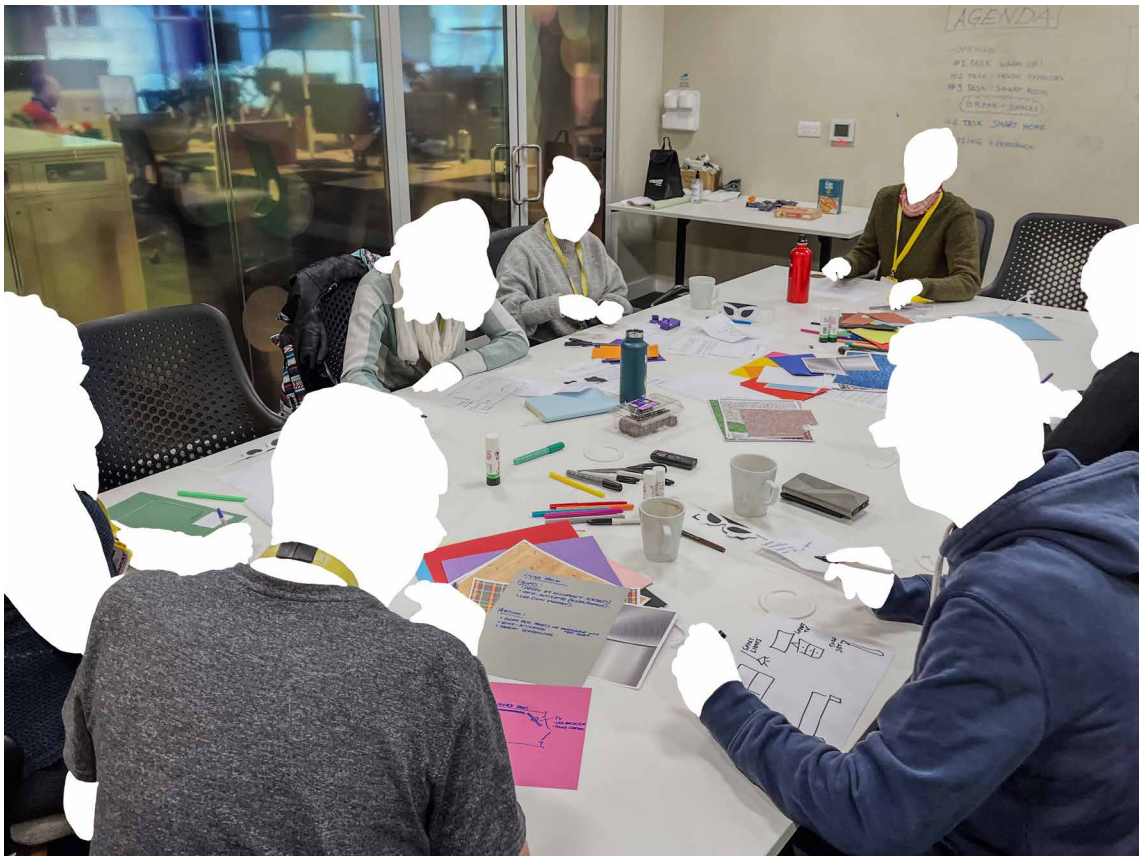


Figure 3.6 - Professional participants designing smart rooms as part of the third activity of Phase 1's exploratory workshop.

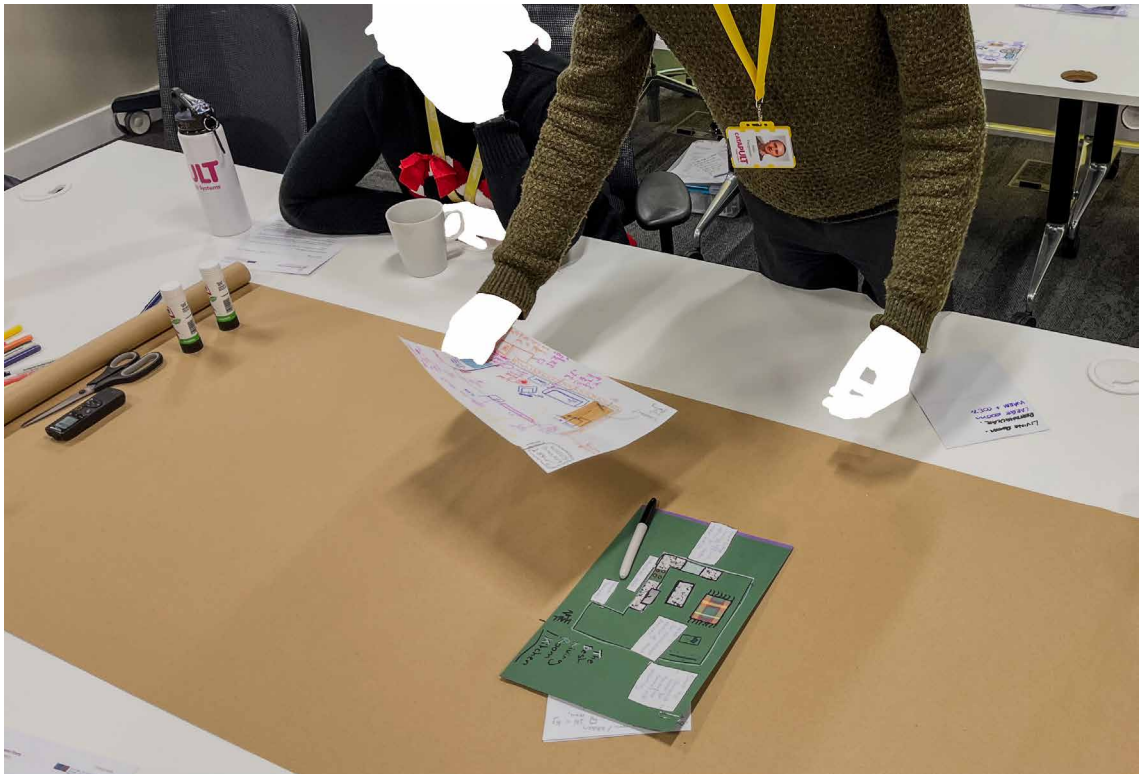


Figure 3.7 - Professional participants initiating the collective discussion to assemble their smart home as part of the fourth and last activity of Phase 1's exploratory workshop.

It was essential to allow participants' existing knowledge to emerge and avoid vocabulary that could prime them. For instance, "smart home" was first mentioned at the end of the second activity, with the question "Which one [of the residential buildings] is a smart home?" Such question was then further elaborated by a short discussion on participants' definitions of smart homes. Their explanation of "smart homes" was kept as a working definition for the day, guiding the subsequent activities.

Using crafting materials for visual representation, participants designed a "smart" version of the rooms coming out of the first activity [Figure 3.6]. In this third activity, the exploration has focused on their current *imaginaire* of SHTs and what they already know about the technology. Thus, participants were explicitly asked not to create new or fictional technologies when designing their "smart rooms". Finally, participants assembled a smart home organising their design of smart rooms together [Figure 3.7]. Co-designing for the first time, participants created narratives for the spatial use of the rooms and its smart interactions. The closing discussion explored the relations between their co-designed smart home with the photo of the residential building previously elected as a smart home.

The exploratory workshops generated qualitative data. For instance, definitions of what is a smart home; how each sample group imagine and expect the external look of smart home to be; or even the range of SHTs they are currently aware of and how they can be integrated in a house. All three workshops from Phase 1 were audio recorded, and all participant-generated visual data were documented. As a preliminary analysis point, the data collected was synthesised so SHTs *imaginaire* could start being characterised in their particularities. The constants, contrasts, and tensions—or troubles—between *imaginaires* were temporally organised in a diagram [Appendix C, Section 2, (vi) Troubles Diagram]. Such diagram had then served as a prompt for participants during the second phase of data collection, detailed next.

3.3.2. Phase 2: Descriptive Workshops

Following the constants, contrasts, and tensions between groups' *imaginaires*, the second workshop employed co-design as a trouble-framing methodology—instead of a problem-solving process [Figure 3.8]. This phase corresponds to the generation of ideas in a traditional design process, meaning that multiple and temporary designs are tested to better formulate the design problems. For this research, the co-evolution of the pair problem-solution (Dorst and Cross, 2001) has been applied as a designerly way of staying with the troubles surrounding SHTs. Advancing the co-design process, the second round of workshops was framed to allow participants to develop their social values and ground them through speculative design (Dunne and Raby, 2013; Ratto, 2011). This in-person workshop [Appendix C, Section 2, (i) Workshop Programme] lasted approximately 2h30min and was performed two times in May 2023—once with a mixed group of Professionals and Early-Adopters in Birmingham, and once with Late/Non-Adopters in Oxford.

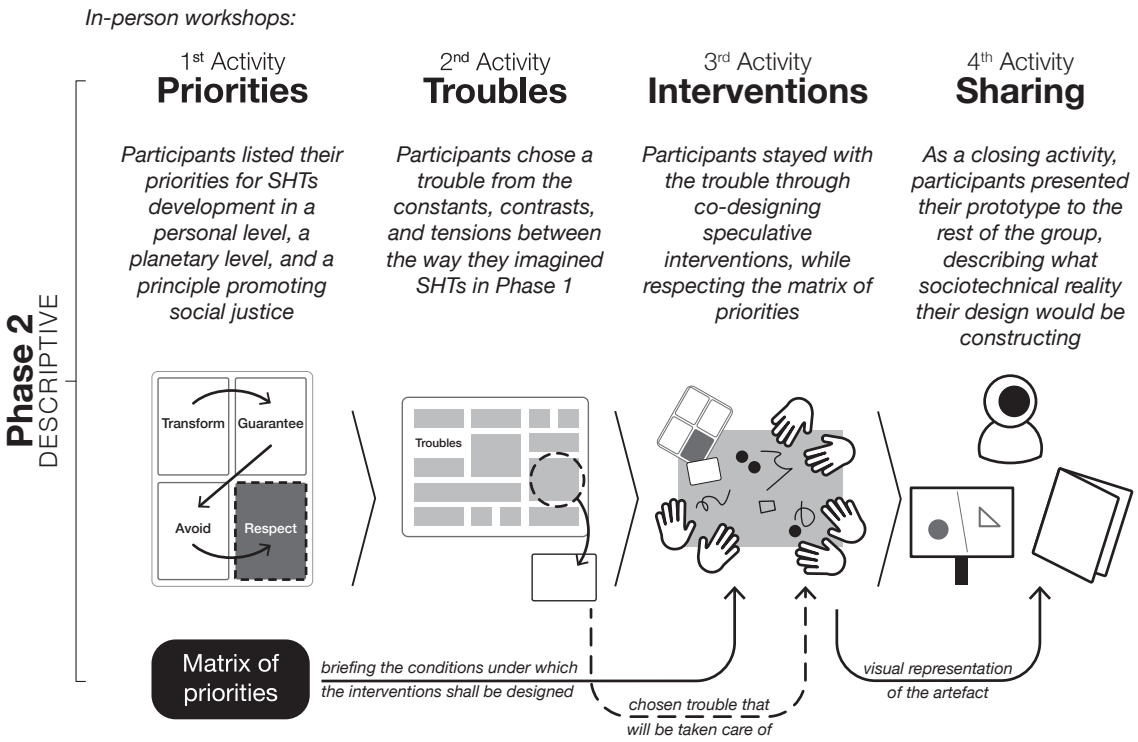


Figure 3.8 - Diagram summarising the flow of activities in Phase 2's descriptive workshops.

A dynamic comprised of individual and group exercises have characterised this second workshop. The first activity [Figure 3.9] was based on practices of values-led design (de Vries, 2009; van de Poel, 2015). As mentioned in Subsection 2.2.2, this participatory design strategy broadly relies on translating publics social values into lists of requirements to be met by technical development. I have proposed, then, that each small group of participants defined their priorities to guide their process of framing SHTs troubles through co-design.

Figure 3.9 - Professionals and Early-Adopters spread over four groups, discussing priorities as part of the first activity of Phase 2's descriptive workshop.

As a form of connection with the previous phase, priorities were first established in relation to what each participant valued the most in their individual domestic everyday life (e.g., convenience). Then, an opposition, with what they would prefer not to experience in their home (e.g., surveillance). After, participants needed to present a social or environmental challenge they believed being a priority to be transformed (e.g., reliance on fossil-based energy). In a deliberative diversification of narratives, the priorities to "avoid" and "transform" didn't come exclusively from participants' individual experiences. Using a supporting slides presentation, participants were prompted with SHTs risks and harmful outcomes, and climate change effects for nature and housing [Appendix C, Section 2, (ii) Supporting Slide Deck]. As such planetary conditions have a complex and interconnected reach, participants stepped away from their personal experience to think and empathise with the collective.

Later, through an open conversation, participants of each small group [Figure 3.10] agreed on a matrix of priorities [Appendix C, Section 2, (iv) Individual Priorities Template & (iv) Matrix of Priorities Template] to be followed by their co-design process. Such a matrix defined how their co-design process helped to transform one's planetary condition, making sure it guaranteed a valuable aspect of their everyday life and avoided undesirable consequences. The matrix reflected participants' "social and cultural values and beliefs" (Galloway and Caudwell, 2018, p. 4) and their will for the co-design process to have a responsible and just impact.

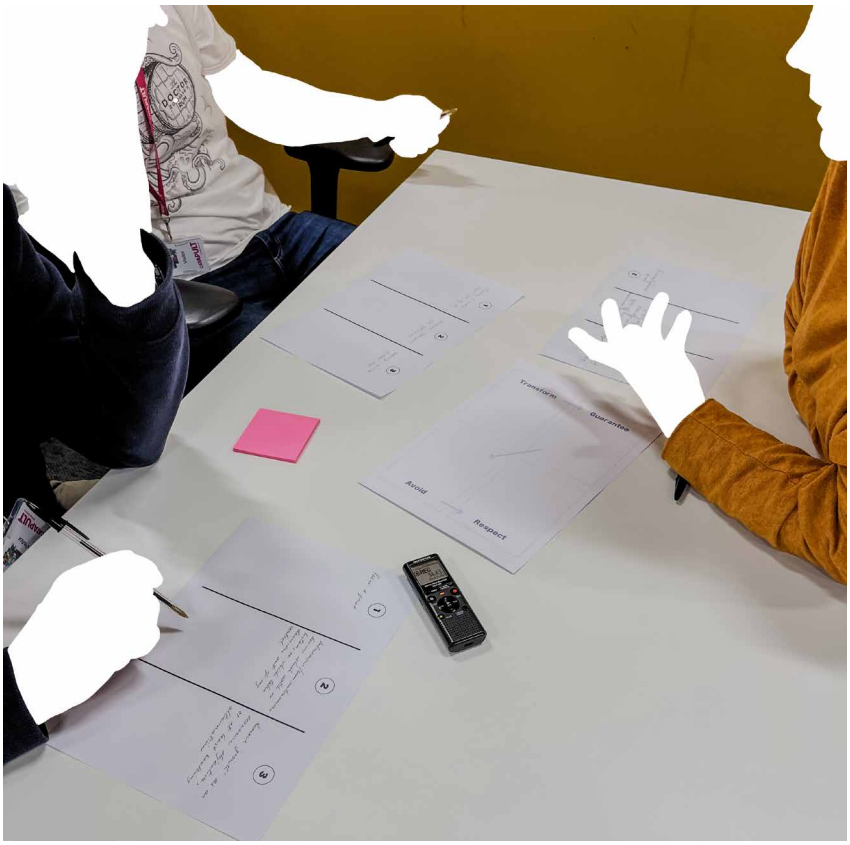


Figure 3.10 - Detail of one group of Professionals and Early-Adopters negotiating the group priorities, based on their individual values, wishes, and concerns, as part of the first activity of Phase 2's descriptive workshop.

As a process of staying with the SHTs' troubles, I have planned disturbances to the co-design using the concept of "wildcards" common to foresight methodologies (Voros, 2006, p. 47). Those were challenges strategically placed throughout the workshop to simulate the unexpected change of circumstances that can happen in any design process, demanding responsiveness and action from participants—also characteristics of Responsible Research and Innovation frameworks.

Completing the matrix of priorities with a social justice dimension, the Superrr studio's Feminist Tech Principles (2022) were introduced as a deck of unexpected wildcards [Appendix C, Section 2, (v) Feminist Tech Principles]. Drawing a card by chance, each group integrated a feminist tech principle to be respected in their co-design. Motivated by the lack of political discussion in previous co-design studies, this wildcard served as a reflective device to consider a more balanced and just distribution of power in the process of staying with SHT troubles. Additionally, feminist principles brought about perspectives historically excluded from the research and development of smart technologies (Søndergaard and Hansen, 2018; Strengers and Kennedy, 2020).

Continuing insights from Phase 1, in the second activity, participants were introduced to a diagram showing initial framings of SHTs troubles [Appendix C, Section 2, (vi) Troubles Diagram]. Such troubles were identified in the preliminary cross-comparison analysis of SHTs imaginaires framed by each sample group during the first data collection phase (this preliminary analysis is documented in Subsection 4.4.2). Prior to the beginning of Phase 2, I organised the identified troubles in a visually appealing diagram, providing not only a more engaging interface with those abstract insights, but also already nudging to their interrelatedness. A printed copy of the diagram was handed to each group and, after further discussing such troubles (or the constants, contrasts, and tensions between samples' imaginaires), they defined one trouble to stay with throughout the subsequent speculative co-design session.

The following third activity of the workshop was an actual designing moment [Figure 3.11 & 3.12], with participants brainstorming ideas of how to stay with the elected trouble, defining ways to better frame and take care of it while satisfying their negotiated priorities. Acting as the researcher-facilitator-co-designer, I have walked around groups, assisting them in grounding their priorities into a prototype representing their speculative way of staying with the trouble. There was a constant discussion on how their design could exist in an alternative sociotechnical reality, or how this reality could look, etc. Even if the artefact being designed was of a metaphorical, non-physical nature, groups were asked to create some form of material manifestation capable of conjuring "societies and cultures" (Galloway and Caudwell, 2018, p. 1) from the sociotechnical reality where their artefact could exist.

To wrap up the workshop [Figure 3.13], groups faced a second wildcard. Using the Tarot Cards of Tech (Artefact Group, 2018; Orchard and O'Gorman, 2024) [Appendix C, Section 2, (vii) The Tarot Cards of Tech], participants needed to foresee possible impacts of their

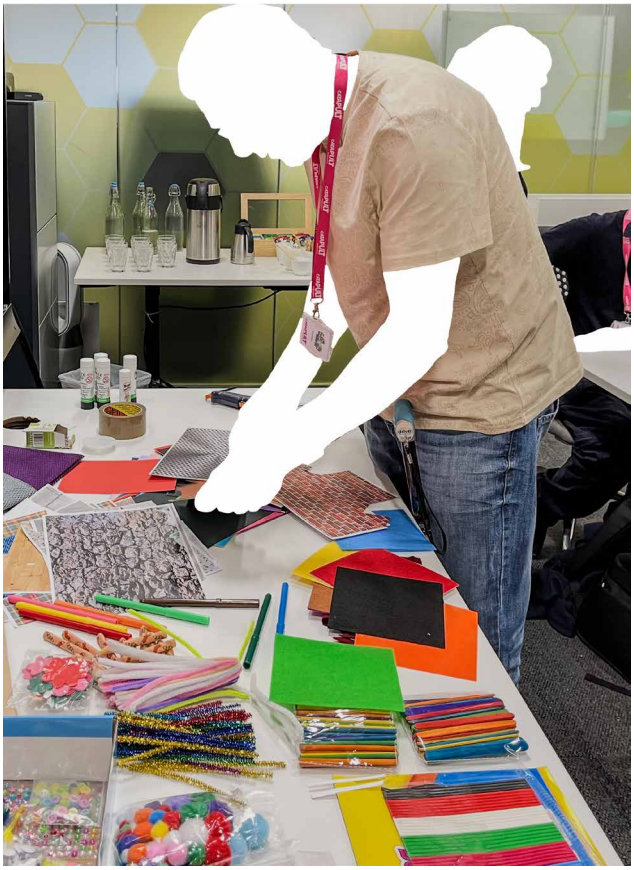


Figure 3.11 - Participant selecting materials to craft the visual representation of their group's way of staying with SHTs troubles as part of the third activity of Phase 2's descriptive workshop.

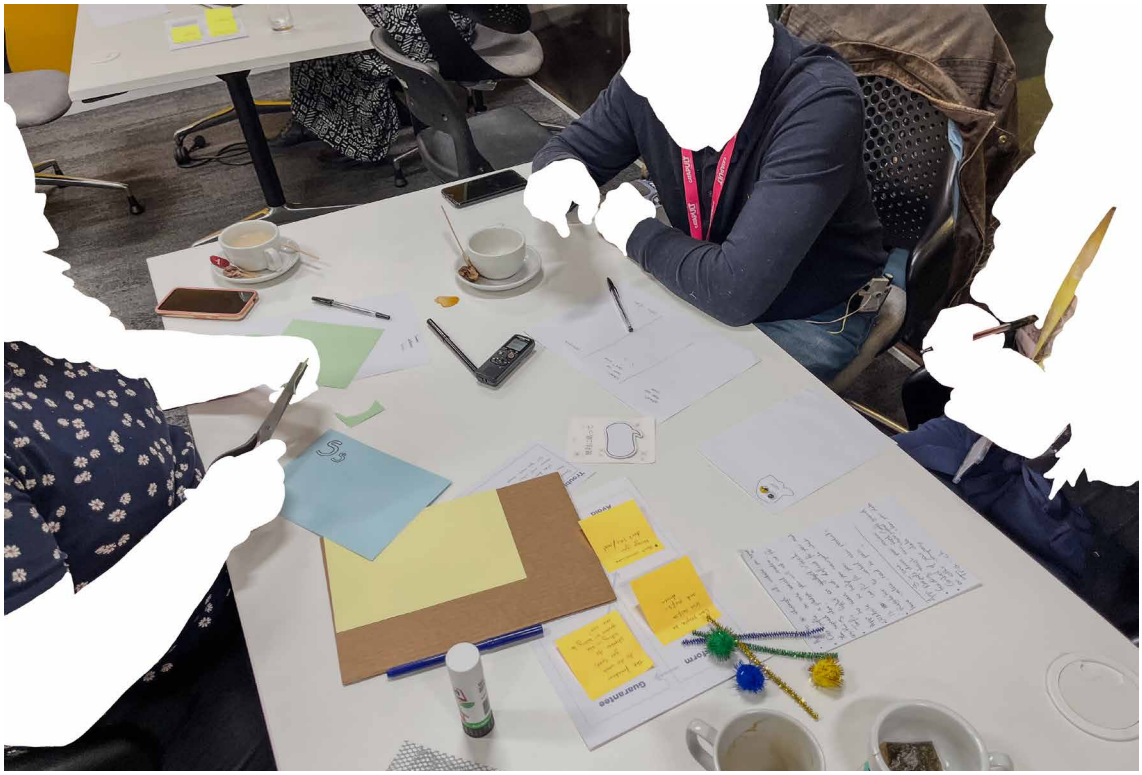


Figure 3.12 - A group crafting their way of staying with SHTs' troubles in an ideation process that respected their matrix of priorities as part of the third activity of Phase 2's descriptive workshop.

Figure 3.13 - Participant showcasing to others their group's visual representation of the way they chose to speculate and stay with SHTs troubles as part of the fourth and last activity of Phase 2's descriptive workshop.

speculative design. Card decks are an established strategy for discussion initiators, and, in this workshop, they have been relevant to raise archetypical questions about digital technology development. Furthermore, I have introduced them to this workshop as an impact anticipation tool, allowing participants to respond and avoid undesirable outcomes, and thus, promoting a more responsible co-design practice for SHTs.

This second workshop also generated qualitative data, like the prevalent priorities for SHTs development from a mixed sample group of Professionals, Early-Adopters, and Late/Non-Adopters; expanded discussions on SHTs troubles; and speculative designs staying with those troubles. As for Phase 1, both workshops in Phase 2 were audio recorded, and all participant-generated visual data were documented. A preliminary analysis of the collected data was performed in preparation for the third phase of the co-design process. Through thematic and graphic analysis, I have generated three prompts: a fictional advertising poster [Appendix C, Section 3, (ii) Fictional Advertising], an episode of a fictional podcast called Smarter Than My House [Appendix C, Section 3, (iii) Fictional Podcast], and an illustration to represent the transformations on Phase 1's *imaginaires* in case of Phase 2' speculative artefacts existed [Chapter 6, Figure 5.8]. Such prompts served not only to keep participants engaged between meetings, but also for them to have time to individually reflect on possibilities not discussed in the workshops.

3.3.3. Phase 3: Prescriptive Focus Group

The third phase continued the speculative discussions of the second workshop, focusing now in prescribing the conditions, knowledges, and processes necessary for the speculative designs to be enacted. In a focus group, participants have reflected on each groups' artefacts, understanding possible similarities and impacts [Figure 3.14]. While still grounding values unto the artefacts, it was also a moment of realization of effects and outcomes that such embodied values have for society and the environment—

which positions this focus group in a late stage of co-design processes. Participants were personally invested "in addressing matters of concern, problematizing connections between society and technology," which then created "deeper conceptual understandings of technical innovation." (Galloway and Caudwell, 2018, p. 5) This online focus group [Appendix C, Section 3, (i) Focus Group Instrument] lasted approximately 1h30min and was performed once in July 2023 with a mixed group of Professionals, Early-Adopters, and Late/Non-Adopters, using Microsoft Teams platform for video calls and a Miro virtual whiteboard [Figure 3.15].

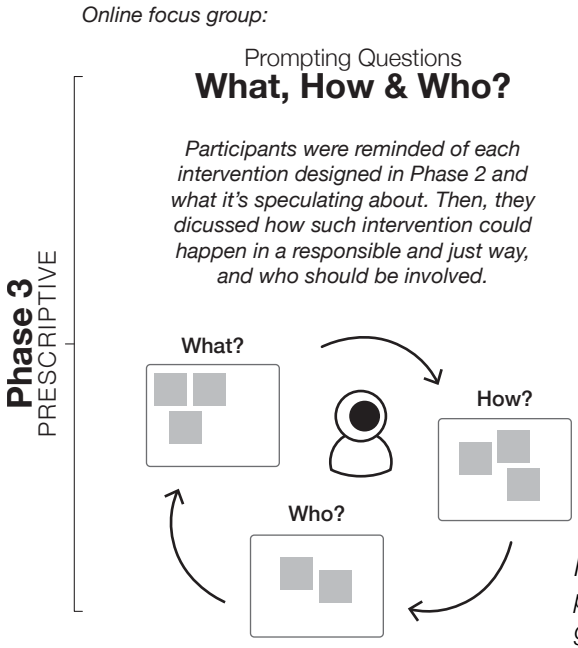


Figure 3.14 - Diagram summarising the flow of prompting questions in Phase 3's online focus group.

As previously mentioned, prompting material was sent to participants in preparation for the online meeting [Appendix C, Section 3, (ii) Fictional Advertising & (iii) Fictional Podcast]. Participants had a chance to reconnect with the speculative designs experiencing them through an alternative and thought-provoking representation—triggering unanticipated deliberations.

The co-evolutionary model of innovation in complex contexts, by van der Bijl-Brouwer et al. (2021), was used as a framework to guide the online group conversation. The original model describes "how *what* is being produced through an innovation process co-evolves with *who* is involved in that production and *how* these actors learn and innovate together." (2021, p. 571) In doing so, participants were asked to further speculate on (i) **what** has been co-designed in Phase 2 and its outcomes (e.g., products, organisations, principles, etc.); (ii) **how** or using which set of knowledge and processes could make such artefacts come closer to exist (e.g., methods, practices, etc.); and finally, (iii) **who**

needed to be involved in the production or enactment of such artefacts (e.g., social groups, specific demographics, etc.) The three questions were applied to each one of the seven co-designed speculative artefacts.

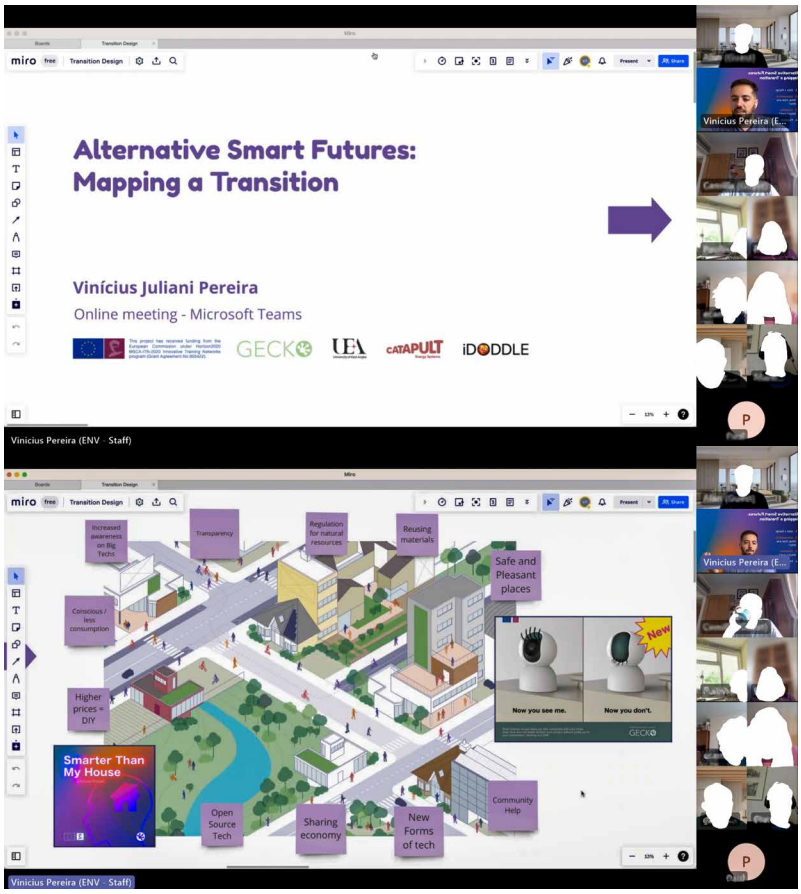


Figure 3.15 - Screenshots of the online meeting and Miro virtual board that supported the online focus group discussions from Phase 3 of data collection.

This focus group generated qualitative data such as a better detailed description of the co-designed artefacts, what would they be and what kind of impacts would they generate; synergies, similarities, and contrasts between different artefacts; social groups and actors that should be involved in enacting them; as well as the necessary processes to make the artefacts (or some of their aspects) possible. As in Phases 1 and 2, the focus group was audio recorded, and any notes taken using a Miro virtual whiteboard.

3.3.4. Phase 4: Evaluative Interviews

The fourth and last phase of data collection presented a meta dimension and evaluated the co-design process itself. After each workshop and the focus group, participants have been asked to fill a short feedback form [Appendix C, Section 4, (ii) Feedback Form]. The form questioned participants whether they felt that the workshops/focus group has

allowed them to experience the expected aspects of a co-design process (e.g., mutual learning, everyday practices-led process, use of design tools, etc.) In total, 18 forms were collected in Phase 1 and 2 each, and 8 forms in Phase 3.

Using the sample cohort that took part in Phase 1 to 3, individuals were invited to participate in semi-structured interviews to reflect on the co-design they have been part of. The interview instrument [Appendix C, Section 4, (i) Interview Instrument] was formulated considering a preliminary analysis of Phase 1 to 3 feedback forms. Even though previous co-design processes have not always presented a final collective meta-evaluation, reflexivity is an essential characteristic of RRI frameworks, and therefore, this evaluative phase was deliberatively positioned as a final realization of social values and narratives prioritised, understanding the strengths and weaknesses of this co-design study. Each online semi-structured interview lasted approximately 1h, and a total of 14 participants took part from all samples, between October to early-November 2023. Microsoft Teams platform was used for the video calls [Figure 3.16].

Figure 3.16 - Screenshots of three of the 14 one-on-one online evaluative interviews performed in Phase 4 of data collection.

The interview instrument was developed in four blocks of questions: first, a set of questions to warm up participants' memories over the process, considering the distance between the interview and the start of the study. Going for a second block focused on the co-design structure and logistics, understanding how participants perceived workshops' activities and methods. The third block of questions introduced a brief description of RRI (Owen et al., 2013) and design justice (Costanza-Chock, 2020) and asked participants to reflect on whether the co-design process has been responsible and just. Wrapping up with the fourth block, participants were asked to evaluate their contribution to the co-design process.

The feedback forms have generated quantitative data that informed the generation of qualitative data through the interviews. For instance, the interviews have been able to provide suggestions for co-design to be more responsible and just; how participants have felt more engaged with the activities. Furthermore, responses signalised in which ways participants felt empowered to replicate ideas, share knowledge, and critically analyse their positions towards SHTs after taking part in the co-design. As the previous phases, all online interviews were audio recorded and printed feedback forms were digitised.

3.4. Data Analysis Methods

In qualitative research, data collection and analysis tend to happen iteratively throughout the research process (Clark et al., 2021). As such, the nature of data being generated over workshops, focus group, and interview, has guided the choice of analysis methods. Here I detail the two analysis methods employed in the research, following the generation of textual data through audio transcriptions, and visual data through participants and researcher drawings, collages, and prototypes.

3.4.1. Thematic Analysis

Thematic analysis (TA) is a method for "identifying, analysing and reporting" themes in qualitative data sets (Braun and Clarke, 2006, p. 79). The TA employed here follows a theoretical approach, as the criteria for identifying themes was known beforehand through specific research questions and literature review (Braun and Clarke, 2006): "It requires pre-existing theoretical and analytic knowledge that gives you the ability to identify the analytic concepts that you're looking for." (Braun and Clarke, 2013, p. 207)

In a theoretical TA, a theme is "a category of interest identified by the analyst" (Clark et al., 2021, p. H94) and related to the research questions and theoretical framework. Themes can be seen as similar to codes or a group of codes—while "A code is a word or brief phrase that captures the essence of why you think a particular bit of data may be useful." (Braun and Clarke, 2013, p. 207) Regardless, themes are built on codes identified during transcription as "Codes provide the building blocks of analysis." (Braun and Clarke, 2013, p. 207)

As demonstrated in qualitative research methods literature (Braun and Clarke, 2013, 2006; Clark et al., 2021), the TA followed the steps below:

1. Familiarization with the data & initial coding – Over 15 hours of audio recordings from the four phases were relistened and transcribed verbatim with the assistance of Microsoft Word automatic transcription tool [Appendix D, Section 1]. Reviewing the transcriptions with initial codes informed by literature review, I started to identify relevant features of the data relevant for answering the research questions. A total of 218 relevant coding features were found in Phase 1, 787 between Phases 2 and 3, and 370 in Phase 4. This initial coding process was conducted in NVivo qualitative analysis software.

2. Searching, identifying, & defining themes – Looking at the initially coded features, I have searched for similarities and patterns that could be clustered in themes. The relevant coding features in Phase 1 were grouped in 13 themes, the ones from Phases 2 and 3 were grouped in 35 themes, and the ones in Phase 4 in 47 themes. The themes identified corresponded to aspects existent in current literature, which were relevant to answering the research questions. For each phase of data collection,

the defined themes were then grouped with their corresponded codes and coding features in a comparative table, where I was able to understand overlapping themes that could be articulated into a narrative. The clustering of codes into themes were produced at NVivo, and the final comparative tables in Microsoft Excel.

3. Evidencing themes – Using the evidence from the coded data, it was possible for me to demonstrate the presence of themes through the results analysis report. Here, links with existing themes in literature were also made. The comparison and results of datasets were registered in Microsoft Word and will be introduced in Chapter 4, 5, and 6.

	Initial Code: **Experiences with SHTs >**	*Coding Features*	Identified Themes	Defined Theme
P4	Part of it is whether you grow up with it or not. Like the house I grew up in had electric storage heaters, and just the idea of a thermostat—There was no point! Absolutely no point. If you could get them working in the first place, which is debatable … So, when I first moved in somewhere with a thermostat that worked and, actually, correctly set the heating temperature I wanted it to, it took me a very long time to get in the habit of using it. Because I have grown up from, you know, 15-20 years just thinking the heating is not worth the hassle …	*If you're not used to have a technology in your house when you're young, it can take a long time to adopt it later.*	Design propositions are linked to personal lay experience.	Expert practice supported by lay-user experience
P3	I think you and I are the same, because we never had a thermostat growing up, and I have never had a thermostat. I just turn the heat off or on, and all the radiators in the rooms, I don't need to, they were always turned on …	*If you didn't have a technology growing up, you might not want it later.*		
P4	I think it's the same think for a lot of technology: what you're used to, is what you find easier to use.	*If you're used to a technology, you will adopt it.*	You tend to adopt technologies that you know or that you have used before.	

Table 3.2 - Examples of the coding features emerging from the audio transcriptions were clustered in themes, indicating prevalent topics being discussed during the workshops. From there, a definitive overarching theme was defined to guide the analysis narrative.

Thematic Analysis
"From a different perspective, it was also possible to find professionals sharing their experiences as adopters of SHTs and providing justifications for their choices during the workshop based on such experiences. This part of their imaginaire is usually overlooked by current research on SHTs, rendering developers and designers as unidimensional experts and technicians. P2 claimed they've "got a lot of home automation in [their] place," using a proprietary light switch automation, while P1 described their use of a smart doorbell, smart heating, and smart speaker. *Professionals that were not currently using SHTs (or lacking interest in using them) noted that the absence of previous interactions with the technology as one of the elements preventing them from personally adopting it or prescribing it in their designs during the workshop: "I didn't put a dishwasher because I don't have a dishwasher and ... I have never had a dishwasher" (P1). For another professional, growing up in a house non-equipped with a centrally controlled heating system (e.g., thermostats) impacted how they imagine such technology as an adult." (Section 4.4)*

Table 3.3 - An example of clustered theme informing the analysis report in Chapter 4.

3.4.2. Textual-Visual Analysis

Visual methodologies are composed of well-established research strategies in social sciences (for anthropology, sociology, etc.) However, there has been a tendency to reduce images' complexities, narrowing them down to an analysable unit (i.e., theme, topic, code). In this case, the image is not considered a "stand-alone" independent data but rather a support to further elaborate textual reports (Brown and Collins, 2021). Such practice can provide academic rigour, but it risks losing visual data's autonomy and strength as research information.

In the overlapping area of creative arts (visual arts, architecture, design, etc.), images and any other form of visual representation are treated as "stand-alone", independent, and analysable data, receiving at least equal treatment as text. This is so much so that, as mentioned in subsection 2.2.2, visual representation integrates the designerly ways of knowing, thinking, and acting (Cross, 1982). Images' autonomy is preserved because visual representation in design practice goes beyond the collection of data and its analysis. As drawings, collages, and diagrams are used to elaborate themes to inform research, their thorough documentation is essential to guarantee academic rigour.

The design nature of the data collection methods described in the previous section, as well as the importance of visual representation as a designerly way of knowing, have indicated the need to incorporate visual analysis methods in this research design. For instance, the *imaginaires'* representations produced by participants in Phase 1 required appropriate analysis methods to elicit discussions and reflect on the contrasts presented by their understandings and expectations of SHTs.

A textual-visual (TV) approach was then elaborated based on Drew and Guillemin's framework (2014; 2010). Now, the compositional interpretation (Rose, 2022) of participants-generated visual data (a methodology close to thematic analysis) has been extended to incorporate a graphic analysis. This last analysis relies on the designerly ways of analysing, augmenting, and knowing described by Tagliari and Florio (2009): the researchers familiarise themselves with the data through the production of visual representations of it. Based on Panofsky's iconological comparison (2019), a third layer of visual analysis was used to test themes emerging from the compositional interpretation and graphic analysis in the face of symbols and images commonly associated with the study's subject. The TV analysis is exemplified next:

1. Participants' Visual Engagement – Using a list of inquiring questions [Appendix D, Section 2, (i) Questions Sample] attributed to Compositional Interpretation (Rose, 2022), an initial descriptive analysis was used to familiarise myself with the visual data. The description was organised inquiring participants-generated images [e.g., Figure 3.17], and, then cross-checking it with participants' notes and audio transcriptions. Participants-generated visual data were digitised and organised using Adobe Photoshop. This first step was completed using Microsoft Word and NVivo's visual data interface.

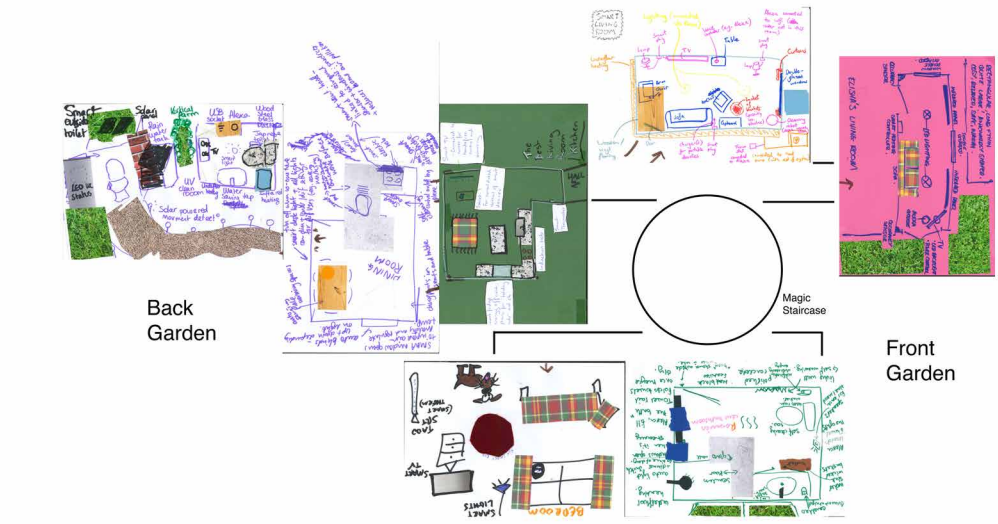


Figure 3.17 - Example of documentation of participant-generated visual data from Phase 1, analysed through compositional interpretation.

Examples of Inquiring Questions (Rose, 2022)		Descriptive Analysis
Who made it?	*Professionals working with smart home technologies.*	
What is being shown?	*A collective collage of a smart home.*	
What are the components of the image?	*Seven A4-sized rectangles with drawings and text composing the collage.*	
How are they arranged?	*They are placed next to each other, not overlapping, with some placed vertically and some horizontally. The arrangement is related to their position in the imagined smart home. The image is also quite horizontally spread.*	
Where is the viewer's eye drawn to in the image, and why?	*To the top-right area, where a big circle drawn on the paper represents a spiral staircase connecting the rooms in the house. In the same area, one of the A4 papers is in a contrasting pink.*	
What relationships are established between the components of the image visually?	*Even if there is no visual representation of links, they are supposed to be connected by doors or corridors as they are rooms from the same house. There's a sense of patchworking.*	
What use is made of colour?	*Colour is mostly found in the use of printed textures to represent grass, gravel, wood, stone, tartan, and felt. Two A4 rectangles were made using coloured paper, so the whole room is in dark green and pink.*	
What is, or are, the genre(s) of the image? Is it documentary, soap opera, or melodrama, for example?	*The representation is both documentary (in a sense they present a clear and straight information on what things compose the home), but also a non-fictional narrative (in a sense that they've imagined ways to use the home).*	
To what extent does this image draw on the characteristics of its genre?	*The representations are mostly in a top view/architecture plan layout view, which is quite common for documenting houses and buildings.*	
Does this image comment critically on the characteristics of its genre?	*There is an exaggeration of electronic elements in the representations, indicating how far one could go with house automation. There is also the presence of gardens surrounding the house but no visual indication of neighbours.*	
What do the different components of the image signify?	*The whole is meant to be a smart home, and each component is a smart room: two living rooms, one outdoor toilet, one bathroom, one bedroom, two kitchens with dining area.*	

Professionals have imagined a smart home as a long horizontal house with two floors and an extensive wraparound garden. The two floors are connected by a spiral staircase. On the ground floor there are two living rooms, one big kitchen with dining area, and one outdoor toilet at the backyard. On the first floor there is one bathroom and one bedroom. All rooms in the house have multiple electronic devices and automations.

2. Researcher's Visual Engagement – In a subsequent interpretative step, the graphic elements composing the visual data have been isolated [Figure 3.18], tracing on top of the original images as a "redrawing" procedure (Tagliari and Florio, 2009). By doing so, compositional patterns, shape contrasts, colour prevalence and any other underlying visual narratives were highlighted. As additional information exclusive to Phase 1's analysis, my interpretation of participants-generated visual data has incorporated the photo elected as the building that looked the most like a smart home. The primary structure isolated in the beginning was then formalised through technical drawing (Tagliari and Florio, 2009)—which, for instance, provided the architectural layout of each floor of the smart homes produced in Phase 1. Then, I produced synthetic illustrations to summarise the themes emerging from the graphic analysis [Figure 3.19]. This interpretative step relied on tracing paper analogue sketching, which was digitised and organised using Adobe Illustrator.

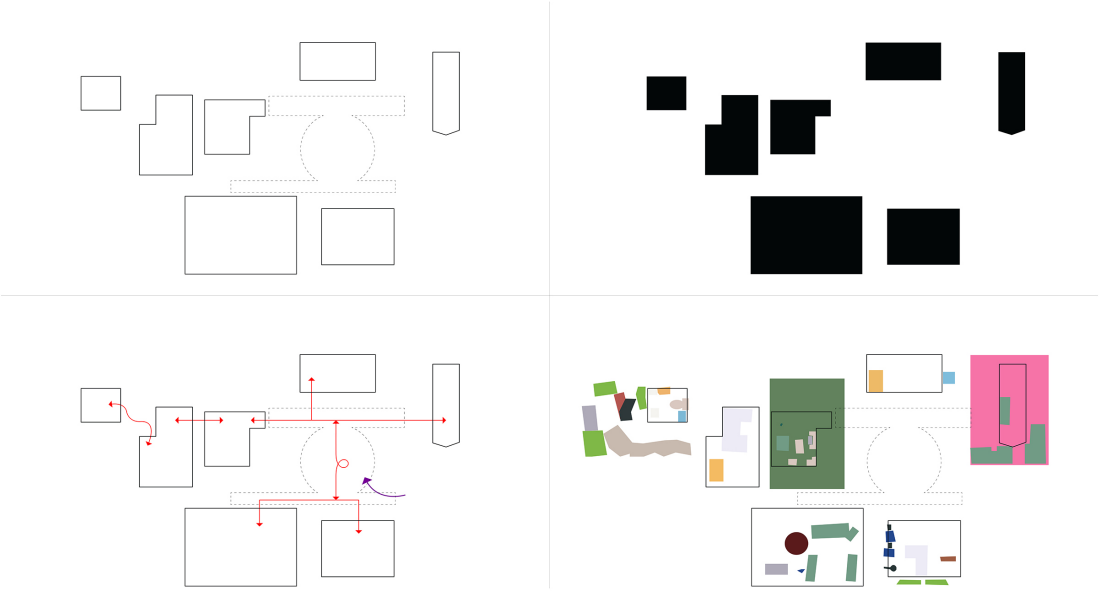


Figure 3.18 - Graphic analysis of participant-generated visual data in Figure 3.17.

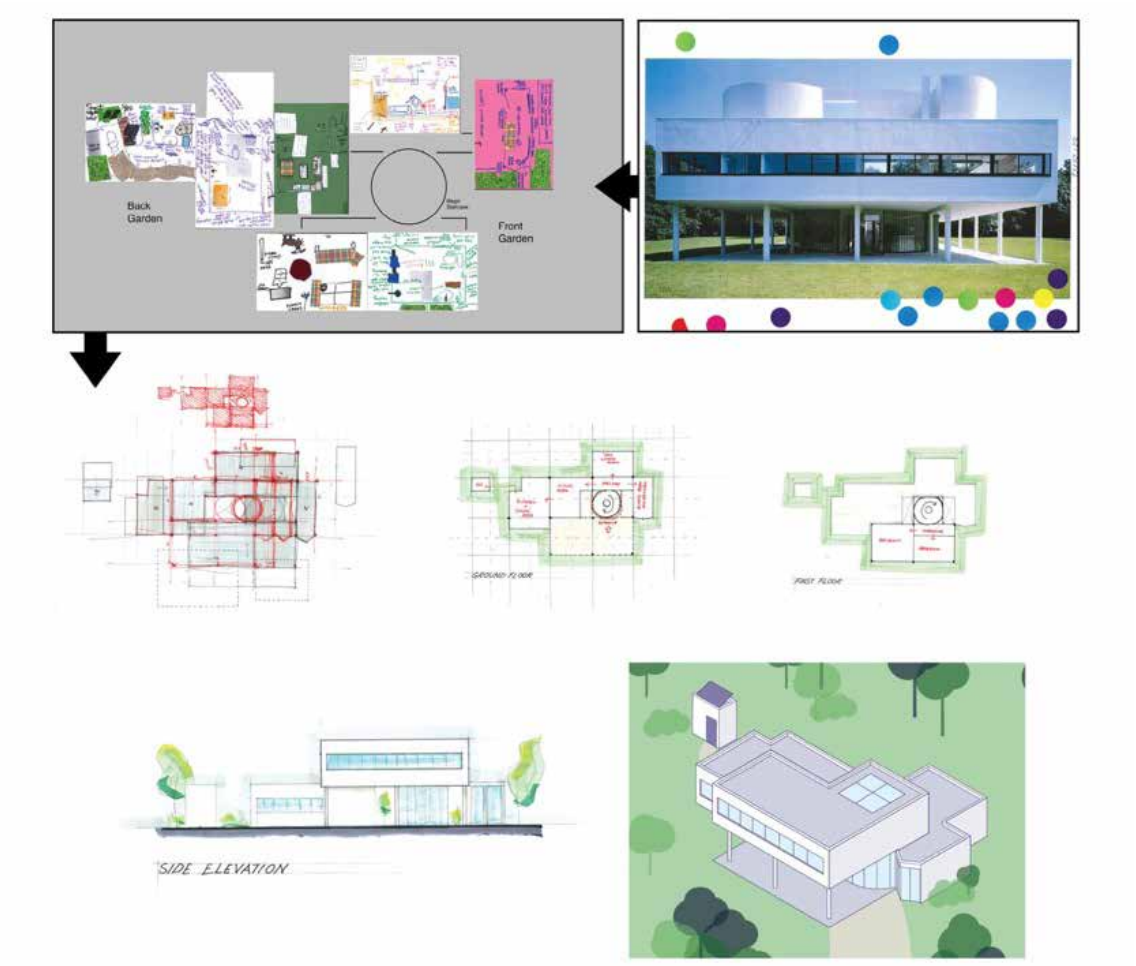


Figure 3.19 - Example of research-generated visual synthesis by redrawing Figure 3.17.

3. Re-Contextualizing Representations – In the last associative step, the visual narratives depicted by the descriptive and graphic analysis extrapolated the visual data collected to establish links to depict enduring symbols, icons, and visual discourses present in participants' *imaginaires*. In Phase 1, for example, this iconological comparison with external images (Panofsky, 2019) has tested the emerging themes and allegories in relation to how participants have imagined current and possible smart home technologies [Figure 3.20]. This step was completed using online search engines like Google Images and was consolidated in the analysis of Chapters 4 and 5

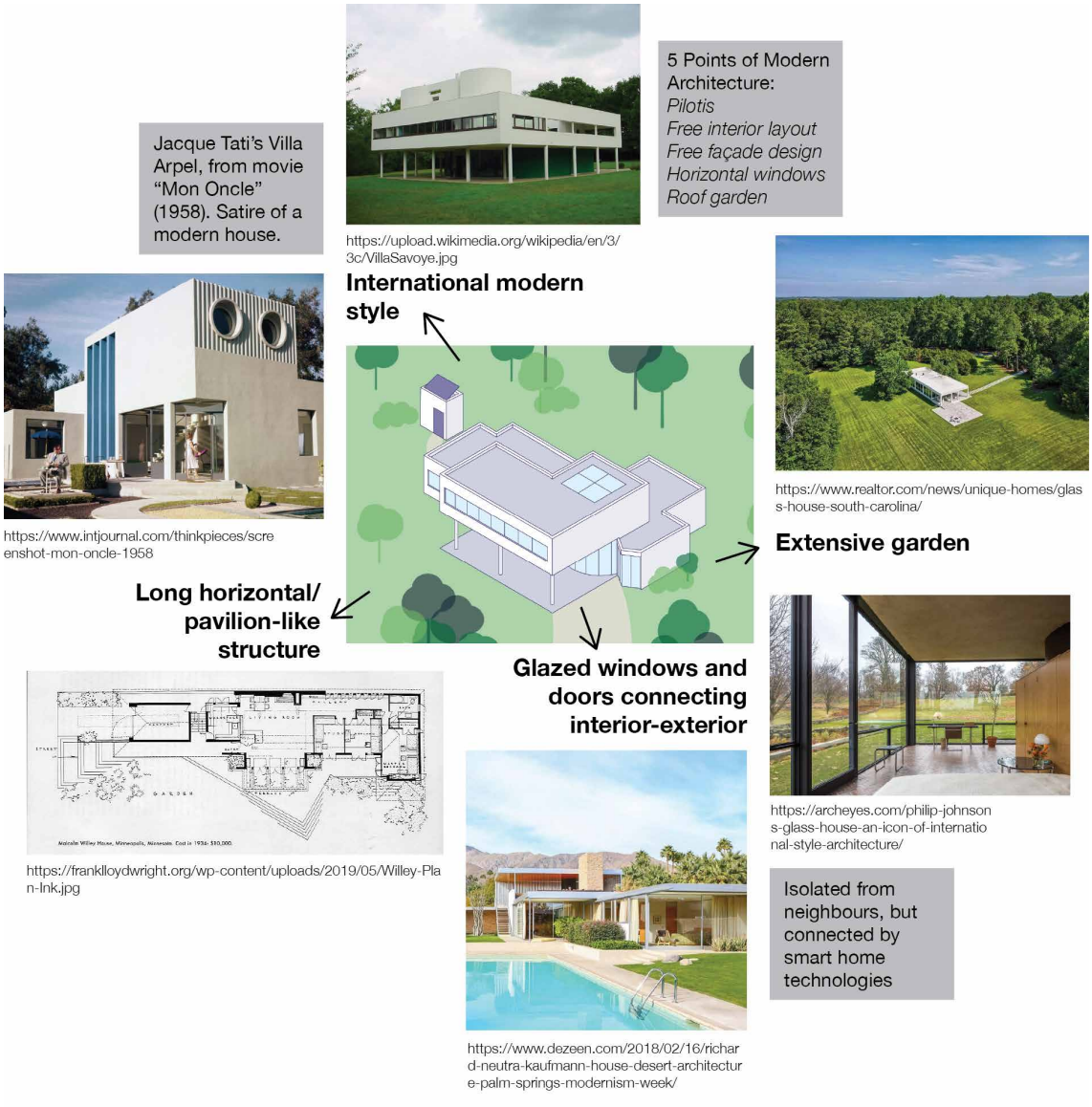


Figure 3.20 - Iconological comparison between researcher-generated synthesis illustration and external images.

TV Analysis of Professionals' Smart Home
"Participants have identified resemblances of their smart home with the detached house chosen by them as the residential building that looked the most like a smart home—and referred to by P3 as "the cool one." Professionals' smart home presented a similar number of windows and glazed doors, a spiral staircase, and number of storeys as Ville Savoye—the detached house presenting an archetypical style of the architectural international modernism. Modern architecture seems to have further inspired participants to visually express their imaginaire of smart homes. For instance, the horizontal spread of Professionals smart home recalls the North American Mid-Century pavilion houses—a style also recognised by isolated buildings with glass façades providing integration with garden exteriors, which is also present at participants representation of a smart home. [...] *Professionals have a conventional modernist aesthetic, still connected to Post-War manifestos of housing, machines, and industrial efficiency. Professionals expressed their smart home in a modern international style, prioritising the efficiency of the building, not experimentalising with layout or features." (Section 4.2.1)*

Table 3.4 - An example of TV analysis informing Chapter 4.

4. Comparing Imaginaires: Setting Smart Home Images in Action

As discussed in Chapter 2, smart homes have been imagined in various forms, and, over time, their technologies have been anticipated to offer diverse features. The expression of different social groups' SHTs *imaginaires* can depict the intentions, values, and discourses those groups allocate to the technology. Parallelly, encouraging diversity through contrasts, dissonances, and tensions between *imaginaires* can lead the way for more transformative co-design practices. Reporting on the results of the first phase of data collection, this chapter will characterise the dominant *imaginaires* behind the development and use of smart home technologies by Professionals[7], Early-Adopters, and Late/Non-Adopters.

Previous studies have applied concepts like sociotechnical imaginaries (Jasanoff and Kim, 2015) to incorporate subjective visions into technology development. Those studies aimed to understand how designers frame consumers or what those consumers want from technology to enhance products and achieve market goals (Andersen et al., 2022; Ballo, 2015; Balta-Ozkan et al., 2014; Rohde and Santarius, 2023; Schiølin, 2020; Strengers and Nicholls, 2017). In contrast, this research places the phenomenon of *imaginaire* (Wunenburger, 2020) as a reflective key to creating rapport between people participating in the co-design workshops. Participants acknowledged their SHTs *imaginaires,* expressing them through visual representations. Once visually grounded, such subjective components have been made available for comparative analysis, depicting the similarities and oppositions of each sample group's *imaginaire* to discourses from industry and media.

7. Preliminary insights regarding the dominant imaginaires of SHTs among Professionals have been published in "Pereira, V.J., Hargreaves, T., 2024. Are you thinking what I'm thinking? The role of professionals' imaginaries in the development of smart home technologies. Futures 163, 103458. https://doi.org/10.1016/j.futures.2024.103458"

A popular claim is that the gap between industry and users is responsible for some undesired outcomes associated with SHTs (Gram-Hanssen and Darby, 2018; Leitner, 2015; Wilson et al., 2015). In this sense, there is an assumed distance between how industry professionals envision, develop, and market their products and how users need, expect, and see the same technology. Accordingly, there was an initial expectation that professionals and adopters displayed contrasting SHT *imaginaires*. However, based on the comparative analysis of the three samples' *imaginaires*, I argue that the differences between their *imaginaires* are not profound enough to cause SHTs undesirable impacts. Instead, the different groups' SHT *imaginaires* seem to respond to similar dominant discourses, enduring the positivist and solutionist approach to home automation since domestic electrification (Aldrich, 2003)—which are more likely promoting irresponsibilities in SHTs development and use.

This chapter is developed in four sections. First, section 4.1 outlines the smart home definitions given by participants. Section 4.2 then introduces the dominant aesthetic expression of smart homes present across the different groups. Section 4.3 then considers the different experiences and knowledge that underpin participants' diverse *imaginaires*. Summarising the similarities and oppositions between *imaginaires*, the chapter concludes by suggesting an apparent flatness to how the three sample groups imagine SHTs—which reveals an overarching dominant *imaginaire* that renders individuals as passive consumers, distancing creative and critical interactions with smart technologies, causing individuals to imagine they might not be capable or empowered to modify, interfere, and co-produce SHTs.

4.1. Definitions of Smart Home and its Technologies

When working with the *imaginaires* of smart homes, limiting the definitions surrounding the technology is not helpful. Instead of providing a fixed definition, I deliberatively allowed participants' individual *imaginaires* to contribute to a working definition, raising characteristics they have cared to allocate to smart homes. In doing so, participants' existing knowledge and experiences were prioritised while they expressed how they imagined SHTs.

The similarities between the definitions of smart homes and their technologies reveal durable aspects of the many *imaginaires* of SHTs produced since home electrification. Yet, different sample groups seem to have distinct expectations of SHTs' added value and how the technology is supposed to be adopted. This section will detail such characteristics associated with SHT. First, each sample group's definitions of a smart home will be introduced. Followed by the most cited types of technologies and the instrumental values participants expect the technology to provide. Lastly, the section presents how each sample imagines that SHT should be adopted.

4.1.1. Professionals (P)

As a group of participants professionally trained to develop smart technologies, Professionals were expected to present definitions of smart homes that included coping with technical uncertainties and having a positive opinion about how their innovations can contribute socially and environmentally. The infrastructure behind this sample's daily work life supports their "innovators" profile (Rogers, 2003)—which, consequently, allowed their *imaginaires* to be more venturesome as occasional risks associated with new ideas can be absorbed by the industry.

Smart Home

When asked, "What is a smart home?" Professionals defined it as "a term" (P4), indicating that "all [of] a house's electrical systems, or at least most of them, are connected and working together" (P4). For them, in a smart home, "all devices should be connected or should be smart" (P5), enabling residents to "control everything with [a] phone" (P3) and possibly helping to "gain a bit of time sometimes" (P6). As it's all "connected to the Internet" (P5) via Wi-Fi (P1), smart homes are also "energy efficient" (P6), and its devices can "be controlled by some kind of energy management" system (P5), responsible for managing "the home, the heating, the lighting, all of it" (P4). With a strong focus on the technical possibilities of a smart home, this definition seems to be based on Professionals' daily work, supported by theoretical and practical expertise, let alone their formal training.

Technologies and Instrumental Value

While representing a smart room, Professionals explored devices and systems that performed the characteristics of the smart home they have defined. Most of the technologies this group mentioned were energy and resources-related (e.g., heat pumps, solar panels, water-saving taps, smart lights, smart electric plugs and switches, smart thermostats, underfloor heating, etc.) The prevalence of smart energy technologies is likely due to Professionals' work focus—in providing energy efficient smart technologies (P5). The group's second most commented SHTs regards everyday life automation, potentially because of its connection with achieving efficiency in energy and resource use, e.g., cleaning robots, automatic watering for gardens, smart curtains/blinds and automatic windows, occupancy sensors, etc. Nevertheless, even with the energy efficiency focus, there was no mention of the opaque environmental implications reported by previous research and media (Subsection 2.1.2), revealing a somewhat naïve framing of smart technologies.

Other irresponsibilities emerging from the widespread use of SHTs were not explicitly associated with the smart home. Even if Professionals' smart homes were heavily equipped with smart electronic devices, privacy, security, and pervasive surveillance concerns were not mentioned. In contrast, P5's interest in smart dishwashers was

immediately responded to by another participant who associated it with the fact that P5 has children. For that participant, the value of technology would only be perceived because P5 is a mother, reinforcing problematic gender assumptions surrounding SHTs. One more time, the way social inequalities are being worsened by the use of SHTs was evidenced by participants' association of household chores automation with unpaid work historically performed by women.

Adoption Strategies

The nature of the workshop exercise asked each Professional to design a room in the smart home separately. Because of that, participants argued that they had not described integrated systems but incremental technologies, which, for Professionals, is not the "ideal" for smart homes. Like in one of Woods' typologies (2024), for Professionals, ideally, a house should be designed and "built to be a smart home" (P2, P3) at a more "fundamental" and "infrastructural level" (P2) instead of having "small individual, almost peripheral smart devices" (P2) added to a regularly built house. Such basic household infrastructure (P2) refers to "core heating, electricity, storage, production possibly, export, and then potentially something called demand-side management." (P2) Following this perspective, "designing it [a smart home] room by room is never *gonna* work out [...] I think, to make a proper smart home, the whole place has to be designed [to be one]." (P4) This *imaginaire* of a house designed in advance to be smart ignores the diverse ways in which domesticity is performed, in order to reinforce a specific type of household idealised by dominant social discourses.

As highlighted by one Professional, "People have different priorities in life" (P1) and "smart additions" are relatable to a home they might live in now (P5) rather than a custom-made smart home. Participants then highlighted that if not designed to be a smart home, a house should, at least, have a joint or centrally controlled system throughout the rooms, "all built-in together." (P4) If they are not integrated, having different and loose smart devices is "not *gonna* make as much difference as having an excellent heating system or a water system." (P4)—a statement based on their professional training and work experience.

Professionals highlighted that there is no need for some household routines or everyday practices to be automated. For example, P4 referred to smart kettles as "fashionable" automation that is "the most useless gimmick thing [they] can think of" because it can "save yourself 30 seconds, which is ultimately meaningless in the grand scheme of your life." (P4) Another Professional mentioned that their "kind of house just doesn't need to be smart," (P3) when referring to their lack of SHTs due to their residence's small size and typology. Acknowledging that some SHTs "may be superfluous", P6 pointed out that they are still "improving your life sometimes." (P6) There seems to be a sense that users are still in control, as they never mentioned the house performing tasks on the resident's behalf—something present among early adopters.

In summary, Professionals' definition of a smart home is characterised by three key points: (1) a house managed by connected logic systems, (2) designed to be smart, (3) to provide energy efficiency. Their definition of smart home didn't raise concerns over the social inequalities, pervasive surveillance, and environmental impact associated with SHTs—instead, Professionals' *imaginaire* condescends with problematic gender dynamics.

4.1.2. Early-Adopters (A)

This section explores how people who are already adopting the technology understand and define it. Early-Adopters have first-hand experience and knowledge of SHTs from using it. This knowledge usually characterises them as opinion leaders, presenting advice and information for potential adopters in their social circles (Rogers, 2003).

Smart Home

For Early-Adopters, a smart home "works around you, and it's got features which would just complement your lifestyle," (A4) making "your life easier," (A2) "so we can all enjoy our [lives] without thinking when we need to set the heater on." (A3) It is capable of doing "the calculations for you [...] so you effectively have to do less work," (A4) while it manages home "systems through algorithms without [you] having to think about them" (A4)—like turning lights on (A3), setting energy use and waste disposal goals (A4), or even "putting a shopping list in." The smart home "just [do] it for you and: ta-dah!" (A1) Smart homes not only reply to your input (A5), but they are also "resilient" and "robust to change," (A5) as they can respond to "context" demands coming from "external factors" (A5)—like adapting the house's temperature according to weather change, "making the best use of things." (A5) This user perspective of the technology is not only related to delegating tasks for smart technologies to perform but also expects the technology to have some form of autonomy over household management. As Early-Adopters, their positive description of what a smart home is show they believe in the technological benefits.

Technologies and Instrumental Value

Like Professionals, the most mentioned category of SHT among Early-Adopters was related to energy and resources (e.g., smart heating, smart lights, smart thermostats, etc.)—which is likely associated with the fact that have been trialling smart energy technologies as part of a Living Lab program.[8] Also, like Professionals, Early-Adopters did not acknowledge the opaque environmental cost implicated in the use of SHTs. Everyday life automation came as the second most mentioned type of technology (e.g., vacuum

8. As described in Section 3.2, the Early-Adopter sample was recruited from the Living Lab program of the Energy Systems Catapult, which is the company where the Professional sample was recruited from.

robots, smart curtains, smart extractor fans, smart shower cleaners, etc.), followed by a strong category that was not that relevant for Professionals, which is technologies for comfort, e.g., heated seats, mood lights, soundproofing, adaptable screen brightness, etc.

The lack of awareness over the irresponsibilities associated with smart home technologies was noticed again. A1 stated that "a mother would love a smart washing machine," in reference to the accumulation of unpaid household work by women with care responsibilities. The comment echoes the existing problematic domestic gender dynamics deepened by the use of SHTs. Early-Adopters' reluctance to give away decision-making power to adopted technologies made a non-explicit nod towards privacy, security, and surveillance concerns.

Adoption Strategies

For Early-Adopters, adopting smart home technologies is dependent on the trust level one can have in the system, as "you're assuming that the algorithms will come up with an answer that you are prepared to accept." (A4) For Early-Adopters, feeling comfortable with SHTs stemmed from being able to retain some autonomy over it, overriding systems even if "some of the difficult decisions [still] needs to be calculated," instead of "taking away the decisions from [residents]." (A4) Participants seem to have framed their privacy, security, and surveillance concerns through technology trust and decision-making autonomy within the house. This can reveal a still initial awareness of how SHTs capture and process data on household routines, and how the technology can be susceptible to malicious actors.

Early-Adopters' belief in SHT benefits was noticed by the absence of participants challenging the usefulness of the technology. It is then assumed that as a group of adopters and opinion makers, this sample presents a positivist technology positionality that is ready to receive technological advancements pushed by industry.

In summary, Early-Adopters' definition of a smart home is characterised by the following three key points: a house that, by the (1) use of peripheral assistive devices, (2) can make household life easier and more comfortable, (3) provided users can retain autonomy to override the system. While their definition of smart home overlooked social inequalities promoted by SHTs and the implicated environmental costs of the technology, Early-Adopters seem to be aware of the privacy, security, and surveillance issues surrounding smart technologies.

4.1.3. Late/Non-Adopters (N)

People slightly interested in SHT or those not willing to adopt them have composed the third sample group. Late/Non-Adopters are usually reluctant to adopt smart technologies. They tend to be sceptic about new devices interfering in their everyday lives, like in previous frustrated experiences. Moreover, Late/Non-Adopters might not

have the privilege of taking risks, therefore enacting a conservative posture. Generally, they prefer to wait until the technology's benefits are of common sense to make a decision or adopt in response to an economic need (Rogers, 2003).

Smart Home

Late/Non-Adopters defined a smart home as a "Technologically orientated house" (N2) that is brought up by technology and can be programmed (N4) to "do stuff that you might or might not need" (N5)—already hinting at their scepticism towards SHTs. It's "a house that, when you walk in, it will do some menial tasks" (N1) with electronic devices coming "on or [going] off, whenever is a convenient time of day for you" (N3) opening and closing blinds depending on the light (N1) or setting a time for the heating to come on (N4). One participant associated smart homes with being "energy efficient", while another one mentioned that they are "sort of focused on sustainability" and "saving energy" (N6). These statements show that the lack of awareness towards SHTs' environmental costs is a constant in the three samples' *imaginaires*. In contrast with Early-Adopters, Late/Non-Adopters' statements about smart homes are far from direct interaction with the technology, as they still evaluate the need or gains of such innovation in their everyday life. The knowledge to define smart homes seems acquired through media, friends, or family (more in Section 4.3).

Technologies and Instrumental Values

In contrast to the other groups, the most mentioned technologies among Late/Non-Adopters do not present a "smart" prefix and are not necessarily powered by AI (e.g., radio, TV, insulation, desk phone, books, radiator, etc.) Participants mentioned "normal hob" and "normal dishwasher," (N2) "non-electric adjustable chairs," (N5) "non-smart lights." (N6) There was a call for the technologies to stop doing stuff on their behalf, allowing them to perform leisure tasks, like watering their plants: "Give me something to do! You know?!" (N6) Such statements seem to respond to an everyday life that values the process of performing household tasks rather than an urgency to finish the tasks in the most efficient way. This potentially stems from the fact that the majority of participants in the Late/Non-Adopters groups were older adults already retired. Furthermore, there is a balanced mention of other categories of technologies, from energy and resources to communication, automating everyday life, and comfort. Also, smart systems are mentioned as "multifunctional" consoles (N3). Interestingly, this group had the lowest overall sum of mentions of any sort of technology, device, or gadget, including the absence of security and privacy technologies.

Once more, participants' SHT *imaginaires* seem to neglect the ways in which the technology can reinforce existing social inequalities. As noticed with Professionals and Early-Adopters definition of smart home, Late/Non-Adopters reproduced problematic gender dynamics when referring to a female voice assistant that wouldn't be obedient enough: "She is not very obedient, is she?" (N4), "She just got a mind of her own." (N2)

Adoption Strategies

In terms of participants understandings regarding the strategies to adopt smart homes, Late/Non-Adopters stated that "any home can be 'smartified'," (N2) as they do not associate "smart" with the home's basic infrastructure itself but "just the control of it" with "wireless stuff" (N2)—contrasting with Professionals' "designed to be smart" *imaginaire* and presenting another of Woods' typologies related to retrofitting a house with smart additions.

Late/Non-Adopters also mentioned frustration with centrally controlled systems because any errors can compromise all household systems (N3, N5). They feel that maintaining different systems and providers can bring resilience to the house: "I think if you've got one thing controlling everything, it might get mind dissonant, take over and decide: 'Right! you can't do this, you have to do that!' [...] So, I have several different systems going. If one gets *bossy* or breaks down, there are others." (N3) Even if the idea of a clear and straightforward solo system may appeal to this sample group, they prefer to "divide and rule," (N3) due to experience with faulty technology in the past. This seems to be a matter of control over autonomous systems, where electronic devices command is centralised at the Late/Non-Adopter user. Even if not explicitly stated, participants' hesitation in giveaway control and their need to be on top of technical errors can be seen as a concern over their privacy. Some of them mentioned that they "don't actually want to have [their] house controlled by one probably clever meter." (N3) They keep "manual overrides on all of it." (N5) So you avoid companies charging you an "arm and a leg" (N5) to fix the system, because "that's the nature of the society we live." (N5)

The resilience mentioned by Late/Non-Adopters could also be integrated into the device's original design while keeping it simple, small, and cheap (N5)—such wish joins their lack of awareness over SHTs environmental impact, as the size and price of technology are directly associated with unsustainable fabrication practices. Regarding the usefulness of SHTs for their context and routine, N2 mentioned that there is no need to use smart technologies if the house is "nice as it is." They continued saying, "If it's a happy space in a home, then it doesn't necessarily need much [smart technologies]." (N2)

In summary, Late/Non-Adopters' definition of a smart home is characterised by the following three key points: (1) a house with technologies from different providers, (2) making domestic technology systems more resilient to failure, (3) which can be programmed to do tasks that you might not need. While their *imaginaire* continues missing

social inequalities and environmental risks of SHTs, their wish to hold on control over smart technologies is based on uncertain suspicion—not on informed critical knowledge about the systemic irresponsibilities spreading pervasive surveillance.

4.1.4. Section Summary

This section has introduced the characteristics each sample group associates with SHTs, and the similar and durable aspects of smart homes present in participants' discourses. Below is a summary table [Table 4.1] of the definitions each participant group gave to SHTs.

	Professionals (P)	Early-Adopters (A)	Late/Non-Adopters (N)
What smart home is	*A house with fully connected and centrally controlled logic systems, capable of* **managing all residences' resources** *usage.*	*A house that can adapt and* **make your life easier** *by doing things on your behalf, so you spend less time doing household chores.*	*A technology-oriented house that can be programmed to do different household tasks that* **you might or might not need**.
Expressive categories of SHT	**Energy & resource** *technologies (e.g., smart thermostat, smart lights, etc.)*	**Assisted living & comfort** *technologies (e.g., vacuum robot, soundproofing, etc.)*	**"Non-Smart"** *technologies (e.g., TV, radio, etc.)*
How should SHT be adopted	*As an* **infrastructural level**, *in a house designed to be smart.*	**Peripheral devices** *that can be installed by you (DIY) or experts, to make spaces multifunctional.*	*Electronic devices from* **different providers**, *working together to make any home "smart".*
Perceived instrumental values	*Smart homes provide energy* **efficiency**.	*Smart homes provide comfort—when you retain* **autonomy** *over the technology.*	*Smart homes can provide comfort—if they are* **resilient** *in case systems fail.*

Table 4.1 - This comparative table summarises the definitions associated with smart homes and their technologies during the exploratory workshops in the first data collection phase.

Professionals' *imaginaires* of smart homes and their technologies are represented by a house ideally "ground-up" designed to be smart—or, at least, fully connected and centrally controlled. For this group, the smart home can manage all residences' resource usage, making the house energy efficient. Professionals believe that, depending on routine and size, some houses don't need to be "smart", and some forms of automation are more useful than others.

When it comes to Early-Adopters' *imaginaires*, smart homes are believed to make your life easier by doing things on your behalf—so you spend less time doing household chores ("doing what needs to be done"). With a promising framing of smart homes being able to adapt, this group sees that part of the benefits of adopting SHTs relies on retaining control over the systems.

Late/Non-Adopters' smart home *imaginaires* are close to a technology-oriented house that can be programmed to do different tasks that you might or might not need. This group of participants didn't know many smart home technologies or smart devices. Still, because they have used other technologies (i.e., mechanical, electronic, etc), they've established their preferences in using different providers to keep house systems more resilient.

None of the three sample groups proposes robust critiques or ironies in their definition of smart homes and their technologies. Even if Late/Non-Adopters did not know many examples of SHTs, there seems to be a generally positive take from their adoption across the groups. It's possible to notice a certain distance between SHTs' definitions and their everyday experiences, almost like their SHT *imaginaire* is informed by external, distant references. Such distance in relation to smart technology can render adopters as passive users influenced by positivist promises.

The sample groups' definitions of smart home technologies are an essential dimension of their *imaginaire*. However, participants have consciously and intentionally presented such characteristics, constituting only part of the metaphors, stories, and verbal symbols associated with their SHT *imaginaire*. As mentioned throughout Chapters 2 and 3, to further understand SHT *imaginaires*, it's essential to analyse the visual narratives and images they carry when imagining smart homes. The visual manifestation of participants' *imaginaires* can reveal durable discourses and intentions that are not easily accessible through text or speech (Durand, 2016; Wunenburger, 2020).

4.2. Dominant Aesthetic Expressions of Smart Homes

As Wunenburger (2020) argues, visual representations get us closer to an object than textual language can. The text relies on symbolic language and signs to mediate a distant observer-object relationship. Visual representations open more interpretative layers when analysing how individuals imagine smart homes than text, transcending what is being described and expressing indirect meanings and intentions. Therefore, this section will analyse participant-generated visual data so a more robust understanding can be framed around the *imaginaires* behind the development and adoption of SHTs.

The dominant aesthetic expression of participants' SHT *imaginaire* is not composed of a uniform set of visual influences but rather a diverse group of references that can construct coherent and dynamic narratives, animating participants' understandings and expectations of the technology (Chapter 2). The dominant aesthetic expression of their SHT *imaginaires* were characterised in three main ways: first, by the external look and typology of the smart home (regarding the activity described in Subsection 3.3.1); second, by the synthetic illustration generated by the graphic analysis of participants, represented smart home; and third, by iconological comparison with related imagery references. This section will introduce the first two points of analysis, while the third will be further approached in Section 4.3.

As described in Chapter 3, each sample group was invited to explore a smart home's expected external look. Reflecting on a series of pictures of different residential buildings, they were asked to consider which residence would have particular features (e.g., safety,

privacy, energy efficiency, etc.) and which they thought looked most like a smart home (Subsection 3.3.1). The selected picture then informed participants latent expectation for a smart home's external look.

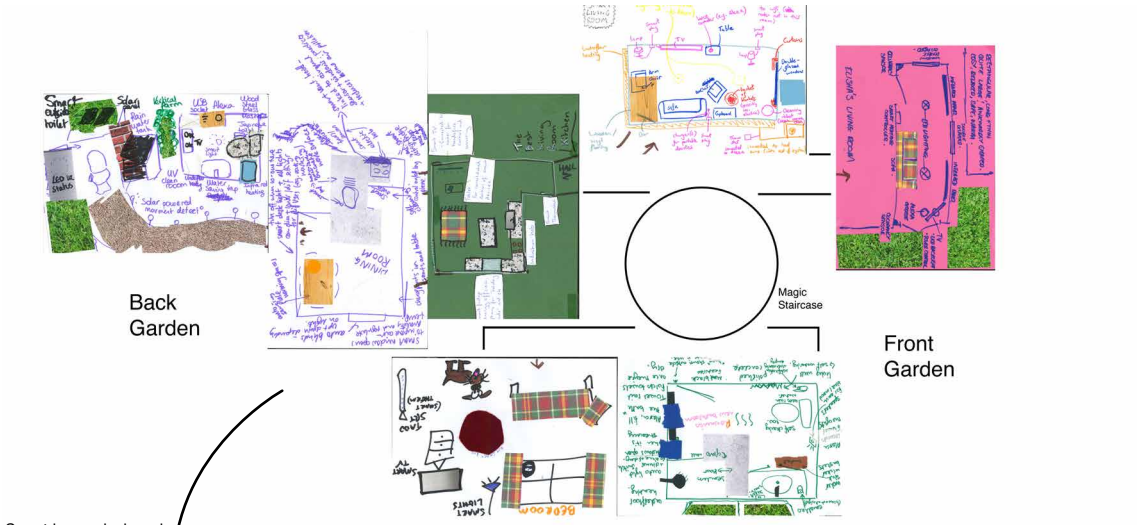
Analysing the collectively assembled smart homes was another way of comparing their aesthetic expectations of smart homes. Workshop tasks asked participants to design smart rooms, which, subsequently, were connected to assemble a smart home. In doing so, the groups generated still, analysable representations of their different SHTs *imaginaires*. The generated smart homes were analysed from two perspectives: first, from the perspective of being a documentary representation, listing the smart devices each group had decided to mention, with a specific layout and aesthetic; second, from the perspective of being a fictional, discursive representation, speculating on a possible journey for householders in their imagined smart home, with specific values and narratives. The graphic analysis of each group's production [Appendix D, Section 2, (i) Graphic Analysis Sample] can reveal persisting aspects of SHT *imaginaires* and specific aesthetic expectations associated with each sample group.

A synthetic illustration of participants-generated visual data was produced to further explore the dominant aesthetic expression associated with smart homes in each group's *imaginaire*. Through redrawing (Tagliari and Florio, 2009), the design of each house was reinterpreted, and its elements were refined and separately compared until their "durable aspects" (Durand, 2016; Wunenburger, 2020) could be visible enough to explicitly transmit the discourses present in their *imaginaire*.

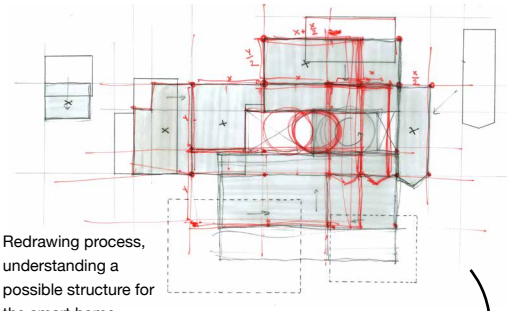
This section will first present a compositional interpretation of each sample's visual representation of smart homes and the expected building typology of such homes. I then present a graphic analysis of the collages produced by each group, depicting participants' dominant aesthetic expectations of smart homes through redrawing and three synthesis illustrations. Each illustration will allow for a more accessible expression of Professionals, Early-Adopters, and Late/Non-adopters' SHT *imaginaire*.

4.2.1. Professionals (P)

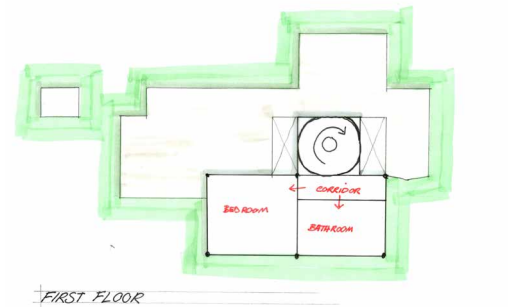
Professionals' graphical expression of a smart home [Figure 4.1] has its main entrance through a "magic spiral staircase" hall (P6), where the first living room on the right attracts attention for its contrasting pink colour, with a long and narrow shape (P2). Next to it, there's a large rectangular "day living room" (P7), followed by a green-coloured smart kitchen (P4) connected to a dining room (P5). Still on the ground floor, after the dining room, "You slide the door, you go outdoor, you have a little gravel [path]" (P6), from which you can find an external smart toilet—or "the best toilet you ever seen!" (P6) There was constant remark of the interaction between the house interiors with the exterior "wraparound" garden (P4)—indicated by a significant portion of green colour and grass texture. On the first floor, you can find a "small and cosy" bathroom with smart

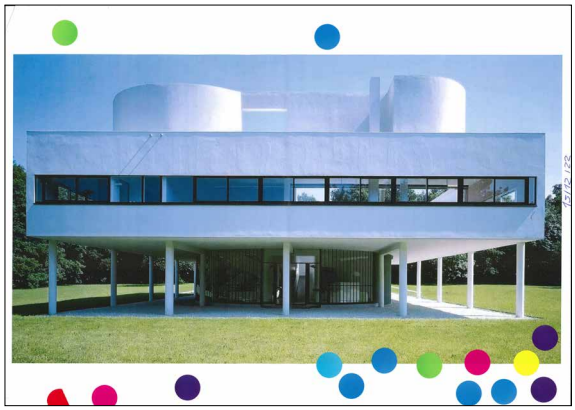


Smart home designed by Professionals.



Redrawing process, understanding a possible structure for the smart home





Residential building that Professionals elected as the one looked the most like a smart home.

Merging redrawing sketches and chosen residence's aesthetics, in a synthetic illustration of Professionals' smart home.

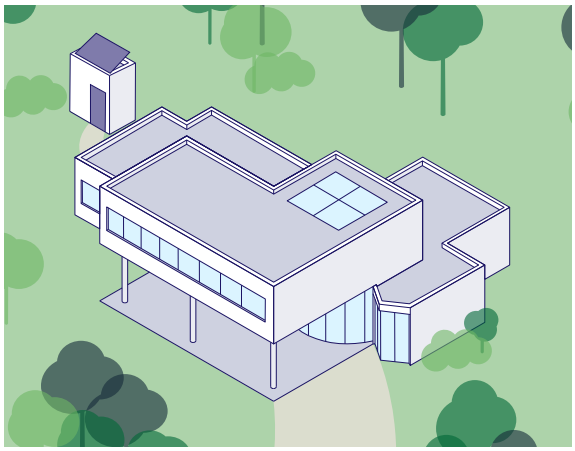


Figure 4.1 - Synthesis drawing of Professionals' smart home.

appliances (P1), a bedroom with "a bird looking through the window" and a "dumb dog [not a smart one]" (P3). The seven rectangular-shaped and individually produced pieces were organically arranged in a horizontal spread, containing drawings, collages, and support texts indicating the presence of non-visible SHT (e.g., underfloor heating). As they have been produced by different participants in the same group, there's a sense of visual patchworking, with textures indicating wooden and polished concrete floors, granite countertops, rugs, tartan, gravel, and plastic.

Participants have identified resemblances of their smart home with the detached house chosen by them as the residential building that looked the most like a smart home—and referred to by P3 as "the cool one." Professionals' smart home presented a similar number of windows and glazed doors, a spiral staircase, and a number of storeys as Ville Savoye—the detached house presenting an archetypical style of the architectural international modernism (Cohen, 2012). Modern architecture seems to have further inspired participants to visually express their *imaginaire* of smart homes. For instance, the horizontal spread of Professionals smart home recalls the North American Mid-Century pavilion houses (Cohen, 2012)—a style also recognised by isolated buildings with glass façades providing integration with garden exteriors, which is also present in participants' representation of a smart home.

Reflecting on the aesthetic expressions of the smart home designed in the workshop with Professionals, three key themes emerged: (1) a large detached horizontal structure, (2) isolated by a wraparound garden, (3) mirroring the aesthetic discourse of the International Modern style from the early 1900s. The aesthetic expression of Professionals' smart home goes in accordance with their given definition of SHTs, as for them, a house should be designed to be smart from scratch—therefore, a new building—and fully automated to be energy efficient—with its "green-friendly" tone represented by the interior-exterior integration.

4.2.2. Early-Adopters (A)

Early-Adopters' smart home [Figure 4.2] has a front entrance with no hallway directly connected to the two main living rooms. The first, on the right, has a big window "so you've got something to look out on," (A5) and it's a focal point with a "bright" and "warm" collage of coloured papers. Extending it, there is a smaller, cosy, multifunctional corner room (A1). On the left, after the entrance, a reading room with the comfort of sound-absorbent surfaces, "lots of books", and "well-positioned windows with pleasant views." (A4) Next to the entrance, you will find a fireman pole and a spiral staircase. Going down using the pole, you land in the cinema lounge basement, with smart protection against humidity (A2). You can climb the spiral staircase to a smart bathroom (A3). The house is surrounded by great views to "look at the distance." (A1) The five rooms were arranged in an ascending diagonal spread, following a mix of representation techniques like the documenting top view perspective viewpoints, one of them being a section perspective

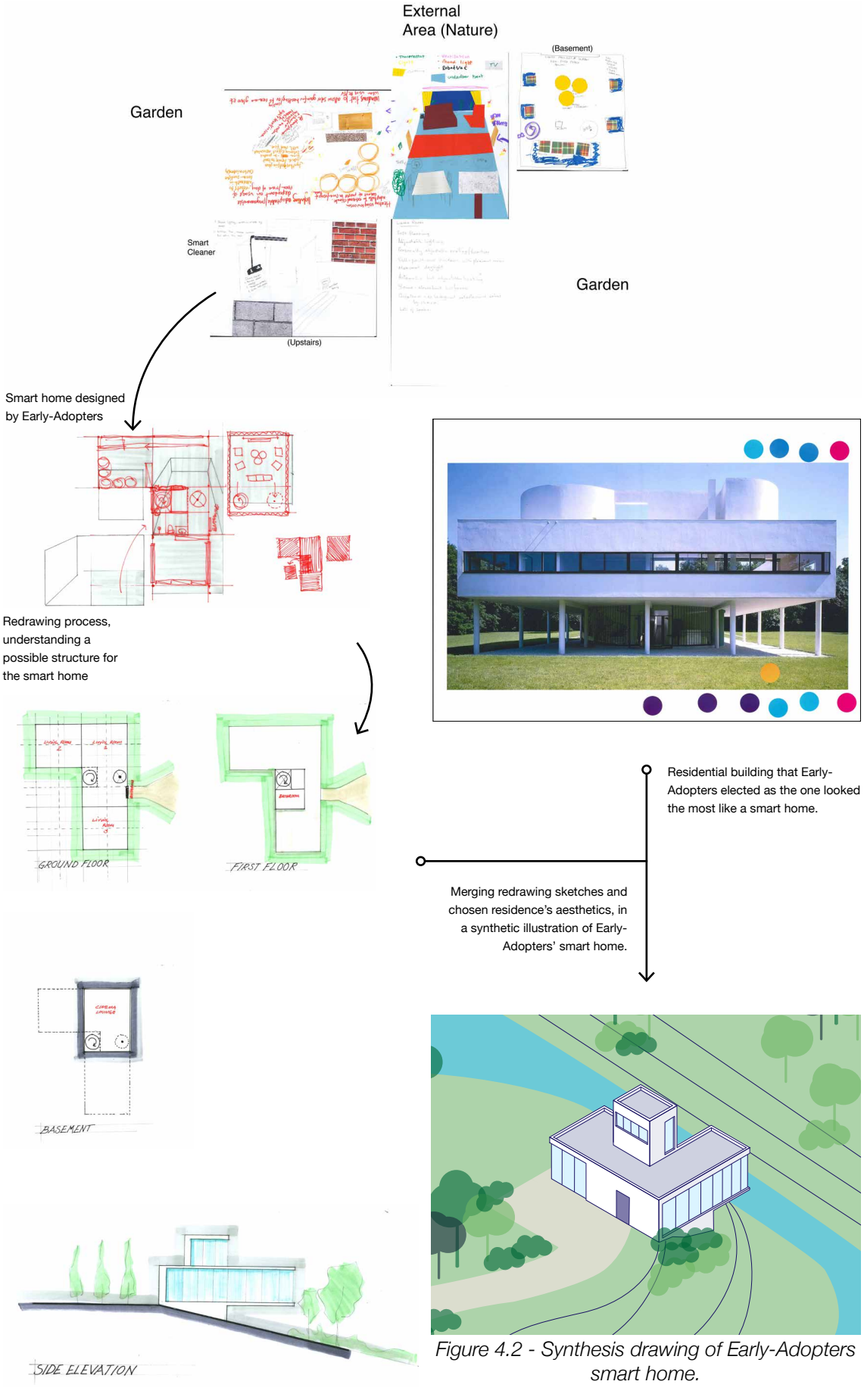


Figure 4.2 - Synthesis drawing of Early-Adopters smart home.

revealing appliances hidden in the floor or walls. Finally, one room was represented through a non-visual descriptive text. Even with diverse techniques, there's a visual coherence, some form of unity, granted by using white spaces and colours to indicate finishing materials and textures.

Early-Adopters expect a smart home to be a detached, modern building. They have selected the same residential building picture that Professional did in their workshop: Ville Savoye. Although presenting similar elements like the extensive glazing and surrounding green park, Ville Savoye lacks the playfulness present in Early-Adopters' imagined smart home—for instance, the firefighter's pole and a basement cinema. Participants further elaborated on this playfulness in terms of their aesthetic expectations for the smart home's interior. Early-Adopters described the use of saturated colours, like the "80's style", evoking a "James Bond" movie as a visual reference (A1). The modern architectural expression of a "Bond-like" technological housing can be associated with the North American Mid-Century style (Cohen, 2012)—high-tech construction materials showcasing the industry's advancements. Hence, it's possible to imagine Early-Adopters as a funky, fully automated remote home that people could retreat to.

Reflecting on the aesthetic expressions of the smart home designed in the workshop with Early-Adopters, three key themes emerged: (1) a small, detached structure, (2) in a remote, retreat-like, isolated context, (3) with a modern aesthetic discourse defined by high-tech playfulness of the Mid-Century style. This aesthetic seems to represent well the definition of smart home technologies given by Early-Adopters in Section 4.1: a multifunctional, adaptative house with assisted living technologies—like a basement soundproofing cinema—that can make the life of residents comfortable as a retreat, as householders would have spy-graded autonomy over the smart technology.

4.2.3. Late/Non-Adopters (N)

With a symmetrical squared organisation of rooms, the Late/Non-Adopters' smart home [Figure 4.3] entrance is framed by two bay windows, leading to a hallway with a staircase. On the right is a multifunctional computer room (N1). On the left is a front living room with another desktop computer console (N3). Further down the hallway, after the staircase, there is a back living room with "electric curtains" to cut lights down for the television (N5). On the right is another backroom with a "non-fossil fuel" fireplace (N6). On the left is a kitchen with "electronically controlled watering" for plants (N2). The first floor has a well-illuminated bathroom with skylight windows (N4). The smart home presents a focal point with a red circle indicating a smiling face, connected to the designed space's narrative elements and emotions, and uses. There is a more straightforward circulation between rooms, with a dominant top-view representation technique. There is a visual unity as participants used similar colours or textures, providing a sense of the individual representations of the same set.

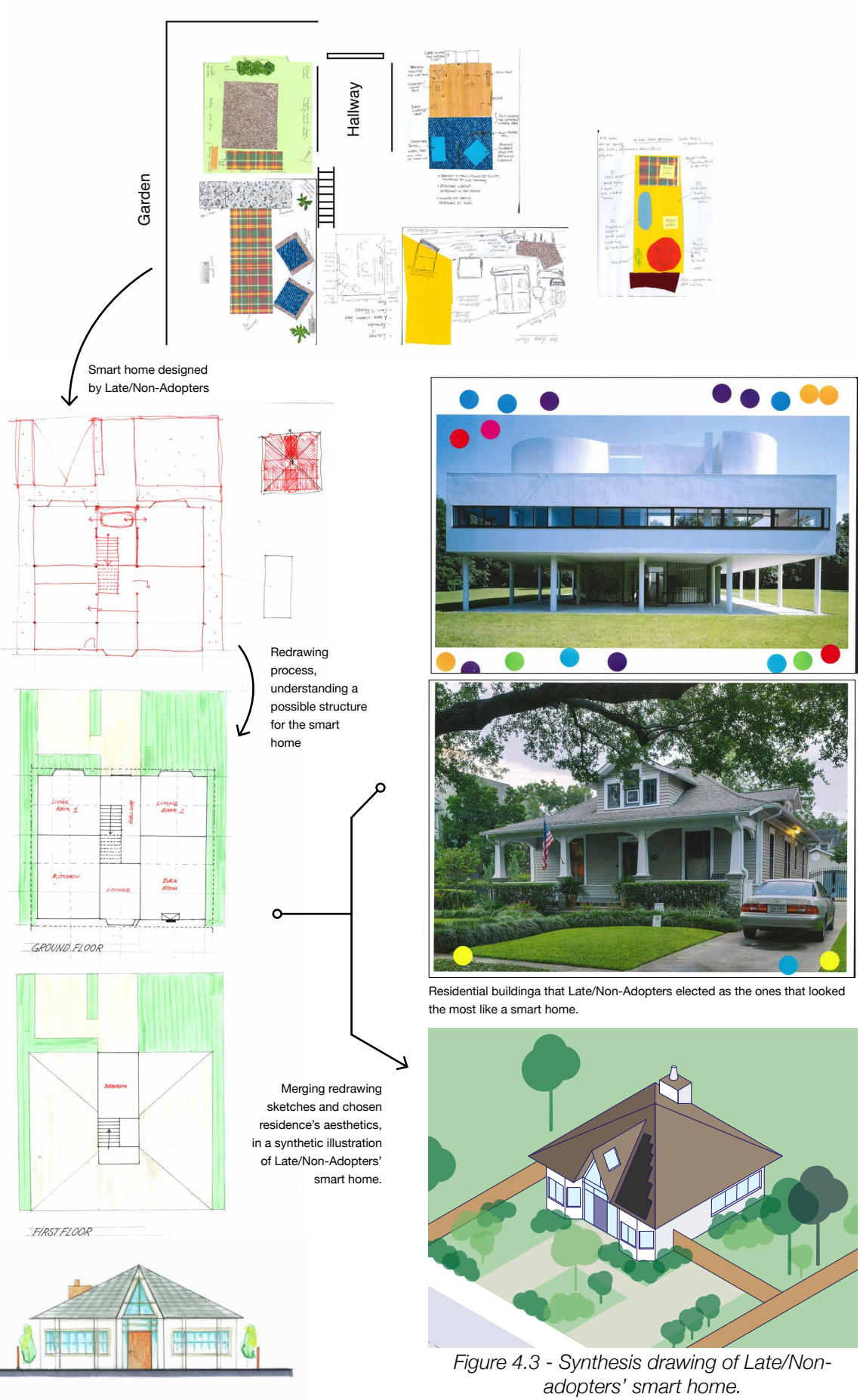


Figure 4.3 - Synthesis drawing of Late/Non-adopters' smart home.

At the beginning of Phase 1's workshop, Late/Non-Adopters elected, once more, the picture showing the detached modern residence Ville Savoye as the one that looked the most like a smart home. However, when such a picture was introduced as the external look of the smart home they designed, there was a general complaint, saying that such an "uber modern" style doesn't look like a home (N2). For Late/Non-Adopters, the smart home they designed has a "heritage look" (N6), with traditional architectural elements such as a fireplace. While they voted for the international modern-style house as the smart home among the different typologies, participants reassessed this decision. They opted to change the external look of their smart home for a detached bungalow in the American Craftsman style (Cohen, 2012), characterised by a front gable roof with overhanging eaves forming a front porch—the bungalow follows a North American interpretation of the British Arts and Crafts stylistic trend, from the late 19th century industrialism critiques. With the decision to change their reference image, Late/Non-Adopters reinforced their definition that any house can be "smartified" by stating a residence's typology is "a social thing [...] nothing to do with smart." (N5)

Reflecting on the aesthetic expressions of the smart home designed in the workshop with Late/Non-Adopters, three key themes emerged: (1) a two-storey detached bungalow, (2) surrounded by a private garden, (3) with a traditionalist, "heritage look" of the 19th century arts and crafts trend. The aesthetic expression of Late/Non-Adopters' smart home illustrates their definition of a technology that can turn smart any house—not necessarily only new buildings. Additionally, the smart home resilience through varied service providers was replicated by choosing the robustness of traditional construction over a hyper-industrialised house.

4.2.4. Section Summary

This section has presented the dominant aesthetic expression of participants' SHT *imaginaries*—i.e., what each group of participants imagines, sees, and expects a smart home and its technologies to look like. These aesthetic expressions interfere with the current design of smart technologies and most likely will continue to frame the future of SHTs. The comparative analysis [Table 4.2] between *imaginaires* revealed both singular characteristics specific to a sample group's *imaginaire* and enduring aspects across all samples.

The specific characteristics of each group were better observed by participants-generated visual data and the synthetic illustration of each sample's smart home. Professionals expressed their smart home in a modern international style, prioritising the efficiency of the building, not experimentalising with layout or features. Meanwhile, Early-Adopters, still engaging with modernist styles, opted for a non-traditional layout that expected a lot of everyday practices to be automated in the background. In contrast, Late/Non-

Adopters deliberatively opted for the bungalow as the most suitable look for their smart home, expressing a more traditional layout that prioritised the resilience of a heritage household life surrounded by smart devices.

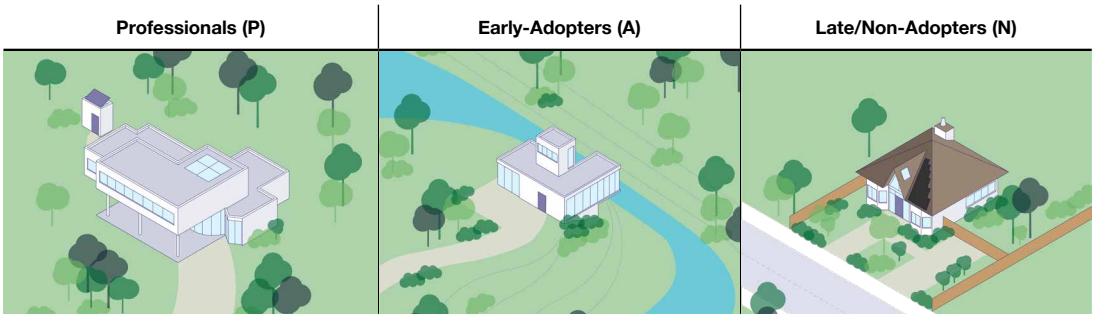


Table 4.2 - This summary table compares each sample group's illustration synthesis of what they expect a smart home to look like.

The enduring aspects of participants' *imaginaire* were most evident when discussing the external look of smart homes. The image of Ville Savoy, a single-family detached house in the international modern style, was chosen by all three samples as the residential building that looked most like a smart home—even though none of the participants mentioned to have ever experienced living in a modern style house. This can, in fact, illustrate the apparent distance between participants' lived experiences and the images they carry in their SHTs *imaginaires* (more in Section 4.3). The similarities in how participants visually represented their smart homes reveal that the functionalism and rationalism present in the late 19th century architectural discourses remain associated with the *imaginaires* of smart homes.

Considering the diverse backgrounds from which participants came, the enduring common elements and the contrasting singularities of their SHT *imaginaries* have equally diverse sources. The following section will introduce the nature of the experiences, the types of knowledge, and the visual references sample groups drew on when imagining their smart homes.

4.3. Experiences, Knowledge, and Images Used to Imagine Smart Homes

People's experiences and existing knowledge are an essential part of their imagination due to *imaginaires* ontological nature (Bachelard, 1971)—or how individuals iteratively produce their *imaginaire* when empirically or metaphorically experiencing things and ideas. During the workshops, space was allocated (Chapter 3) for the three participating groups to express the references that usually help them imagine a smart home and its technologies. Such references reinforce durable aspects of the *imaginaire*, persisting through definitions and aesthetics of SHTs.

This section will first introduce the relationship between expert knowledge and everyday life experience and how they can mutually influence decision-making in SHT development. Then, the visual references mentioned by participants from popular culture to public buildings will be presented. Finally, the section elaborates on the idealisation of a domestic space through smart homes.

4.3.1. Expert Practice and Everyday Life

Owing to the Professionals' profile and work at the forefront of the UK's energy transition (Chapter 3), they were expected to rely on their formal training and previous work cases to indicate and prescribe technologies for the smart rooms during the workshop. Some Professionals have justified their technology choices for the smart rooms based on prior successful work experiences. For instance, as P2 stated, some previous real-world testing with voice assistants has shown its efficacy in communicating with a "smart controller", getting accurate settings such as heating a room at 1ºC: "It gets what you mean, it works really well."

Another expression of the Professional sample's expertise came up while discussing the terminology employed during the workshops. For them, there is an issue with the overuse of the "not clearly defined" terminology "smart," (P2) and how it sometimes misleads people to believe that a device is performing a task using "intelligence" (P2). For example, this Professional mentioned smart meters as "simply a data gathering device. It doesn't think intelligently, it cannot make decisions, it cannot perform actions, what it only does electronically and wirelessly, effectively, is collect data." (P2) Using the prefix "smart" does not make an object smart. "True smartness", according to P2, is linked to "useful algorithmic control", with devices anticipating needs and having the autonomy to make decisions and act—this definition of "true" smart devices seems aligned with Aldrich's *imaginaire* of the Attentive Homes (2003) highlighted in Chapter 2.

This discussion about the term "smart" appears to come from P2's professional expertise, which enables them to critically assess the capabilities and limitations of different devices using their technical knowledge and training. With this experience, Professionals are essential in challenging common sense generated by marketing strategies that may not correspond to the computing power of "smart" home technologies. The concept of smart was not a concern of other samples, nor was it challenged by any other participant.

Parallelly, it was also possible to find professionals sharing their experiences as adopters of SHTs and providing justifications for their choices during the workshop based on such experiences. This part of their *imaginaire* is usually overlooked by previous co-design research on SHTs, rendering developers and designers as unidimensional experts and technicians. P2 claimed they've "got a lot of home automation in [their] place" using a proprietary light switch automation, while P1 described their use of a smart doorbell, smart heating, and smart speaker.

In parallel, expert-level advice from non-professional participants was also seen among Early-Adopters of SHTs. Among this group, A2 referred to their experience in installing, programming, and using smart home technologies and documenting the journey in a personal blog on how to make a house net zero. Such experience parallels the *imaginaire* of a DIY experimental smart home (Woods, 2024). For instance, A2 suggested to another Early-Adopter in the group that the grey water from the smart bathroom designed by A3 during the workshop could be used by the group's smart home underfloor heating system.

Another interesting aspect of Professionals' lay-user experiences relates to adopting SHTs in ways not expected or prescribed by the original developers—where, just like any other user, Professionals "workaround" adapting the technology to their specific needs and routines (Larsen et al., 2023). For instance, P6 uses a smart plug with a timer to turn on appliances in a holiday home "so people have the impression someone is at home." (P6) Or P5 uses motion sensors to switch on lights in an entrance hall so they can see if their children have arrived back home.

Professionals who were not currently using SHTs (or lacking interest in using them) noted that the absence of previous interactions with the technology was one of the elements preventing them from personally adopting it or prescribing it in their designs during the workshop: "I didn't put a dishwasher because I don't have a dishwasher and … I have never had a dishwasher." (P1) For another professional, growing up in a house non-equipped with a centrally controlled heating system (e.g., thermostats) impacted how they imagine such technology as an adult:

> "Part of it is whether you grow up with it or not. Like, the house I grew up in had electric storage heaters and just the idea of a thermostat … there was no point! Absolutely no point, […] So, when I first moved in somewhere with a thermostat that worked and correctly set the heating temperature […], it took me a very long time to get in the habit of using it." (P4)

Here, there is a point of contrast between the Professionals and Late/Non-Adopters group. While Professionals concluded that "it's the same thing for a lot of technology: what you're used to, is what you find easier to use," (P4) Late/Non-Adopters mentioned that the previous contact with technology led to them not adopting it. Late/Non-Adopters' previous and, at times, frustrating everyday experiences with technologies also provided them empirical expertise to advice on the use of electronic technologies or service providers (e.g., telephone, internet, computer, etc.). The presence of such expertise demonstrates critical thinking towards household automation and was highlighted when this group discussed the heating efficiency of houses: according to Late/Non-Adopters, for instance, a semi-detached or terraced house is "easier to heat" and is "energy efficient" (N3, N5). Additionally, the layout of rooms and the position of a staircase in a semi-detached house can influence the heating pattern and energy expenses (N4).

4.3.2. Visual References of Smart Homes

When discussing the smart homes assembled in the workshop, Early-Adopters and Late/Non-Adopters explicitly brought up external visual references to support their discourse and describe how they imagined a smart home. Here, it's important to remember how the images and representations one has had access to throughout one's life will integrate the living and mutable *imaginaire* over a specific topic or theme (Wunenburger, 2020). This section integrates the iconological comparison (Subsection 3.4.2) of the sample's smart home design and reference imagery brought into the workshops by participants or to the analysis process by me.

When making sense of the house circulation and how to access the upper floors after using the fireman pole to access the basement, Early-Adopters have mentioned the transportation tubes (A1) found in the Hanna-Barbera's cartoon "The Jetsons" (1962), a space-age sitcom following the fully automated life of the Jetson family [Figure 4.4]. Another Early-Adopters participant reacted to their smart home, stating: "It's starting to sound like an airport!" (A4), as a reference to a highly automated and industrialised construction. The picture of Ville Savoy (selected by all samples as the one that looked the most like a smart home) was associated with the cartoon sitcom also during Late/Non-Adopters' workshop: "That's quite Uber modern. I mean, even though it may well be an old building, it looks like The Jetsons." (N2) As a very popular production, it's possible to say that The Jetsons may have been, for many people, the first animated representation of home automation, inhabiting their *imaginaire*, with its memory being called back when such topic is presented.

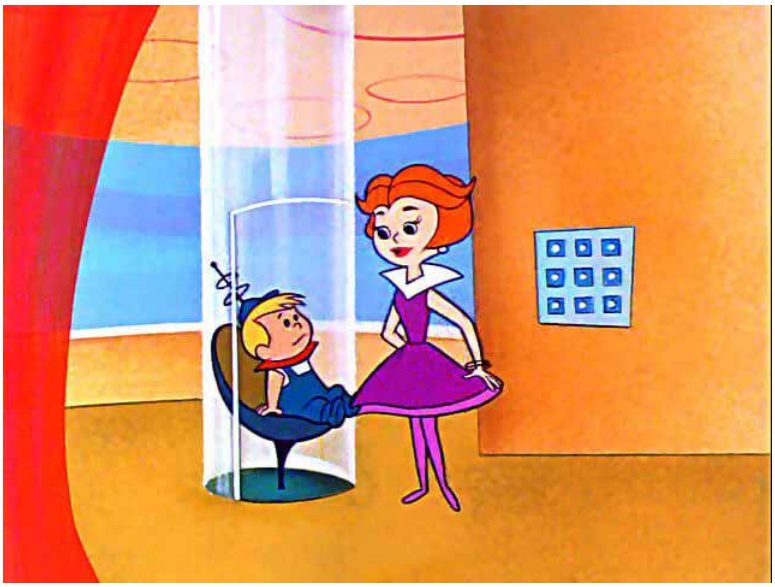


Figure 4.4 - Still from The Jetsons depicting the transportation tube, source: https://greenerideal.com/news/technology/0511-are-pneumatic-garbag-systems-the-future-of-waste-disposal/

The description of the interior design and style of the smart rooms also used external images and visual referencing. For instance, the Early-Adopter A1's "small and cosy" room had "warm colours and textures" with a "flickering neon" faux fireplace "that was very hot in the 80s style". The same participant mentioned the similarity of the smart home they've just assembled with an isolated "James Bond-like refuge". A popular reference to James Bond retreats is John Lautner's Elrod House [Figure 4.5 & 4.6], the scenario of the feature film "Diamonds Are Forever" (1971). The 1980s interior design, finishings, and furniture are well represented by the installation in the Designmuseum Denmark, in Copenhagen [Figure 4.7], packed with manufactured prints and textures, the pervasiveness of shining plastic being shaped in various forms, and highly saturated artificial pigments. In this highly saturated scene, Ian Flemings' fictional character, James Bond, can be found wearing high-tech gadgets and gizmos.

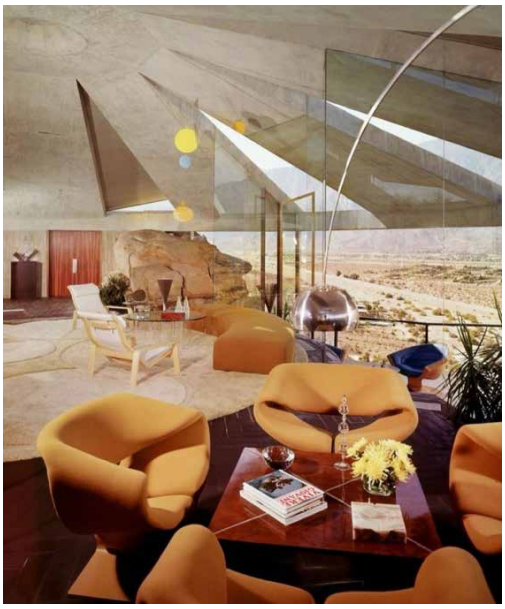


Figure 4.5 - Interiors of Elrod House, by John Lautner, source: https://worldarchitecture.org/architecture-news/czfhh/elrod-house-by-john-lautner.html

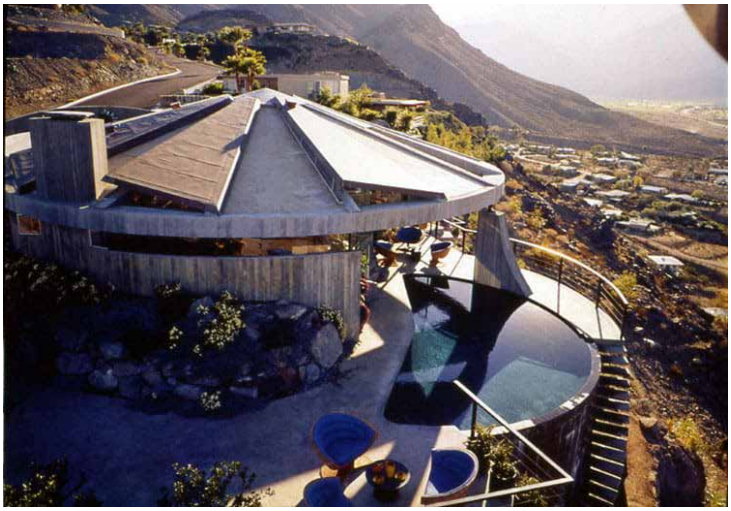


Figure 4.6 - John Lautner's Elrod House from above, an isolated retreat. Photo by Leland Y. Lee. Source: https://www.threads.net/@ilovegreeninspiration/post/C-CPAeKIwXp/is-someone-not-a-john-lautner-fanthe-elrod-house-in-palm-springs-designed-in-196

Figure 4.7 - The 80's inteorior design installation in the Designmuseum in Copenhagen, source: https://depositphotos.com/editorial/copenhagen-denmark-may-2018-danish-museum-art-design-museum-decorative-233228320.htm

A distinct characteristic of the smart home assembled by Late-Non-Adopters is the presence of traditional architectural elements—e.g., bay windows and fireplaces—and participants' decision regarding the external aesthetic and typology of the house when choosing the bungalow as the best fit for the smart home they have designed.

For Late/Non-Adopters, the picture they initially selected as the smart home (the detached modern Ville Savoye) was later criticised for not looking like a private house. For N3, Ville Savoye reminded them of the institutional building of St Catherine's College [Figure 4.8] in Oxford, designed by the functionalist Danish architect Arne Jacobsen in the early 1960s. For N6, their smart home has "a tinge of heritage" in all the rooms they have designed, with a "warmth and a sort of human feeling". Hence Late/Non-Adopters' decision to reposition the typology and external style of their smart home as a detached American Craftsman bungalow [Figure 4.9].

Figure 4.8 - St Catherine's College in Oxford, by Arne Jacobsen, 1962. Source: https://www.dezeen.com/eventsguide/2022/08/arne-jacobsen-and-st-catherines-college-a-conference/

Figure 4.9 - The Abernathy-Shaw House in the Silk Stocking District of Talladega, Alabama, built in 1908. Source: https://en.wikipedia.org/wiki/American_Craftsman#/media/File:Abernathy-Shaw_House_c.1908.jpg

4.3.3. Idealised Home

Based on Late/Non-Adopters' conversations on which residential building better represented their smart home, it was possible to notice participants expanding the topic of smart home *imaginaires* towards idealisations of the home. It was no longer about automation or smart devices but personal aspirations and idealisations for an ideal home. In the early years of house electrification, smart homes were an aspirational ideal for the future of living. A plan idealised by positivist technology discourse. Thus, it's possible to say that Late/Non-Adopters (and probably the other samples as well) had been responding to the questions of what a smart home should be based on what they had effectively been told it would look like (e.g., The Jetsons' home). The fact that the three samples elected the Ville Savoye as representing a smart home is the materialisation of an *imaginaire* animated by the positivist technology discourse.

However, in the case of Late/Non-Adopters, their personal histories and experiences as home dwellers have prevailed over modern discourses of how a home should be. In the end, they prioritised a smart home formulation that responded to their needs and wishes for a house. In the context of SHT development, a rushed co-design looking for the inclusion of users to enhance a product (like the previous studies analysed in subsection 2.3.1) does not allocate enough time for the emergence and maturing of preferences in partner participants. For instance, if applied through a solutionist process, the residential buildings activity from Phase 1's workshop would consider only the first response of Late/Non-Adopters, ignoring the complexities informing their SHT *imaginaires*.

Additionally, the missing parts for each sample's smart homes to be considered "homely" were made clear by participants when reflecting on their final visual representation. Considerations about the layout, size, and typology of the houses were brought up by all samples, as well as what individuals prefer or not to have inside their smart homes. P4 stated that "everyone would prefer to live in a house that is entirely yours. There is no shared space, there's no lobby, no lifts." This statement resonates with Professionals limited vision of an ideal smart home that is designed to be smart, ignoring other forms of living (e.g., shared, collective, spontaneous). Other Professional participants balanced this statement by mentioning that an ideal home "depends [on] when you are in your life" (P6). The ideal home is then directly connected to one's moment in life, which was also mentioned by Late/Non-Adopters when considering the restriction of movements that come with ageing (N5). Moreover, for Early-Adopters, a home must have "a place of interaction" (A4) where people could congregate informally "without necessarily sitting down and putting their feet up" (A4)—which reinforces the collective aspect of domestic living.

4.3.4. Section Summary

This section has introduced the experiences, knowledge, and references brought up by participants when imagining their smart homes in the first workshop [Table 4.3]. Individuals' empirical or metaphorical contact with elements representing SHTs was expected to emerge when expressing their *imaginaires* around the technology. These experiences are associated with each sample group's technology adoption profile and everyday life and can also reveal the external origins of some enduring discourses.

Professionals' expert work and decision-making are not only informed by their formal training and work experience. As lay-adopters themselves, Professionals' everyday domestic life and adoption journeys also inform their expert decision-making. In parallel, Early-Adopters and Late/Non-Adopters also produced expert-like advice based on their direct interaction with smart and non-smart technologies. The samples shared advice within their groups on how they have adapted SHTs to their domestic context, exploring diverse and alternative uses of devices.

Participants started by using their empirical and metaphorical experience to justify their decisions regarding the assembly of the smart home. However, due to the visual nature of *imaginaires*, using external visual references to explain arguments was prevalent among Early-Adopters and Late/Non-Adopters. Distant from participants' everyday lives, pop culture icons like The Jetsons and James Bond movies were evoked as a shortcut for them to explain and complete the design of their smart homes. When such images are brought up in a conversation, other individuals with the same reference framework will start using the references to better understand what is being said. Nevertheless, these "imported" images are references designed by third-party actors, most likely with a set of social values and beliefs alien to participants—who just consumed it through media.

	Professionals (P)	**Early-Adopters (A)**	**Late/Non-Adopters (N)**
Experiences	*Expert decision-making also informed by professionals' experiences as lay-adopters.*	*Empirically acquired expert-like knowledge; 1980s interiors style; pop culture with James Bond and The Jetsons.*	*Interactions with "non-smart" electronic devices; modern brutalist buildings; and pop culture with The Jetsons.*

Table 4.3 - Summary table comparing experiences used to imagine smart homes.

After sharing their experiences and recalling visual references to smart homes, participants started to focus their discussions on a much broader aspect of domestic life. At some point, all three samples made claims about an ideal home, its typology, location, and structure, almost projecting essential household elements that smart home technologies seem not to afford.

The experiences and references mentioned by participants can reveal what is (in)forming their SHT *imaginaires*. Together with statements regarding smart home definitions and aesthetic expectations, it is possible to characterise the dominant SHT *imaginaries* coming from Professionals, Early-Adopters, and Late/Non-Adopters. From an initial analysis it's possible to say that the supposed "gap" between how industry and users imagine SHTs might not be the direct cause of the irresponsibilities in technology's development and use. The following section will introduce the claim that the dominant positivist discourses in the development and use of SHTs tend to standardise *imaginaires* of the technology, preventing the emergence of contesting and alternative sociotechnical systems.

4.4. Comparing Imaginaires

This chapter has characterised the dominant SHT *imaginaires* in the groups of Professionals, Early-Adopters, and Late/Non-Adopters. The analysis of data collected in the first phase of this research could frame the broad definitions given by each group to smart homes. Additionally, based on the visual expression of their *imaginaires*, it was also possible to represent the dominant aesthetics that each group associated with smart home technologies. Finally, the information and images brought up by participants during Phase 1 have revealed what kind of knowledge and experiences support their imagination of smart home technologies.

For an inattentive eye, participants' *imaginaires* seem aligned with the positionality expected from their sampling profiles. For instance, it was expected that Professional participants would refer to their work experience and technical knowledge when expressing how they imagine smart homes. This goes in line with the claim that SHTs' undesirable outcomes are a result of a mismatch between stakeholders' understandings of the technology. However, the thorough thematic and visual analysis employed in this chapter allowed me to recognise subjective elements composing participants' *imaginaires*. In the case of the Professional sample again, it was possible to identify references to their personal experience as users of smart technology when justifying their design choices. Therefore, I claim that actors participating in the development and use of SHTs present complex, multidimensional perspectives. As such, they have as many differences as similarities in how they imagine smart technology. Thus, the supposed distance between industry and users becomes irrelevant in justifying the irresponsibilities surrounding SHTs.

The differences and similarities in how the three sample groups have imagined smart homes are evidenced by the comparison analysis of definitions, aesthetic expressions, and experiences. Unlike the supposed knowledge gap between computer science and social science, the points of contrast between samples' *imaginaires* are relative to participants' experiences and subjectivities. The tensions and resistances emerged because participants need and expect different things from the same technology.

Meanwhile, the identified similarities between the samples' *imaginaires* reveal a common origin in narratives enduring since the electrification of the home. The definitions, aesthetics, and experiences the samples share characterise some form of standard, flat, pre-conceived way to imagine SHTs. From this point, as their *imaginaires* share funding durable narratives, it seems to me that the remedy for SHTs undesirable outcomes is no longer to make different stakeholders see the technology in the same way. Rather, to encourage alternative and contrasting framings for a more responsible and just sociotechnical system with SHTs. As it will be further explored in Chapter 5, I suggest doing it by following Haraway's call on staying with the troubles (2016) of SHTs.

This final section will further elaborate on the identified flat or standardised forms in which all three samples have imagined smart home technologies. After preparing the grounds for a speculative co-design process in the next chapter, I will summarise the comparison between participants' definitions of smart home, the aesthetics attributed by them, and the recalled experiences, highlighting the emerging tensions, contrasts, and oppositions.

4.4.1. Flat Imaginaires

Previous studies have indicated a gap between industry and consumers as the reason for SHTs producing undesirable outcomes (Gram-Hanssen and Darby, 2018; Wilson et al., 2015). This distance between those who develop SHTs and those who use them is associated with the lack of interest in the social aspects of the technology when compared to the focus received by computation and data processing (Leitner, 2015). Such an argument brings about an assumption that if industry and users are not in contact, they must have different expectations over the same technology—which could be addressed through inclusion in technology design processes (Stahl and Coeckelbergh, 2016), aligning stakeholders' perspectives.

Based on the analysis of the expressions of Professionals, Early-Adopters, and Late/Non-Adopters' *imaginaires*, however, I claim that the differences between industry and consumers' expectations are not strong enough to explain SHT negative outcomes, such as deepening inequalities, pervasive surveillance, and environmental costs. Rather than a gap, the comparison of the sample's *imaginaires* revealed the prevalence of a common narrative that has been enduring since the past century (Aldrich, 2003). The dominant *imaginaires* behind the development and use of smart home technologies are positivist,

functionalist, and neoliberal perspectives of a Western type of everyday domestic life. They have a clean white, modern, and industrialised aesthetic, usually informed by references to what future home was promised to look like in the past.

Such discourses do not invite audiences to co-create visions and *imaginaires*. Individuals receive them ready, being rendered as a passive audience. Individuals are not expected to cultivate practices of critical imagination, but they can surely choose a colour of preference for the smart home door. These external, ready-made discourses of SHTs can lead to a flat and standardised automated domestic experience—as they don't encourage dissident and alternative household arrangements.

To keep its relevance, powerful social actors (like the industry) tend to reinforce the dominant SHT *imaginaires* by keeping a distribution of technology benefits and risks that privilege their authority. The current design of SHTs, for instance, prioritises technical possibilities and straightforward solutions for growing profits in the consumer electronic market. The uneven access to technology and the impact of worsening existing social divides are then capable of maintaining the industry's *imaginaires* as dominant while weakening the capacity of distinct social groups to critically express alternative representations of their sociotechnical systems. In doing so, the lack of diversity in how smart homes are defined, seen and imagined leads to irresponsible and unjust futures.

Thus, I argue for the need to intentionally cause disruption and agitate flat *imaginaires* to promote the reflectivity and critical thinking necessary to develop more responsible and just technologies. There is a need to focus on technology's troubles. As framed in Section 2.4, I propose the use of Haraway's concept (2016) through co-design to trouble the irresponsible and unfair sociotechnical systems enacted by current SHTs. A "trouble-focused" co-design implies not only dedicating time to the contrasts, dissonances, and tensions (Sharma et al., 2023) presented in each group's smart home representations but also challenging prevalent assumptions directly connected to the maintenance of uneven access to SHTs' benefits and risks.

The detailed thematic and visual analysis of participants' SHT *imaginaires* not only grounded my previous claims regarding how similar they are. The comparative analysis revealed subtle tensions, oppositions, and silent contestations in how the three sample groups define, picture, and refer to smart home technologies. The following subsection will present the preliminary framing of the troubles emerging from current SHTs *imaginaires*.

4.4.2. Emerging Tensions, Oppositions, and Contestations

This subsection will analyse the tensions, oppositions, and contestations emerging from the comparison of SHTs *imaginaires*. I have produced a comparative table [Table 4.4] that follows the thematic analysis coding of results from Phase 1 of data collection (Sections

3.3. and 3.4). The table summarises participants' statements that potentially hold some tension with other sample statements or existing literature on the theme. Next, I will briefly elaborate on the emerging troubles.

		Professionals	Early-Adopters	Late/Non-Adopters	Troubles
Definition	Smart Homes	*Energy efficient and all house's electrical systems are connected working together.* *Everything is WIFI connected, there's optimisation through Internet.* *Smart tech can control home systems because all devices are "smart".*	*It can control your energy use, and the amount of waste thrown in the environment.* *Can make your life easier, managing house systems according to your lifestyle. It does the thinking for you, does things at the right time, so you do less work and can enjoy life.* *Smart homes are robust to change in external factors (like weather).*	*Energy efficient and sustainable ("make you save energy").* *It's about controlling and doing things in the house, so you don't have to—regardless of you needing it or not.* *It's brought up by technology and can be programmed ("technology-oriented house")—but not all devices are "smart".*	- There's evidence of a rebound effect in the use of SHTs, increasing energy consumption). - SHTs can provide comfort, but it can also be annoying, interrupting, and disturbing users' routine. Users have extra work with faulty smart devices. - Some people don't want SHTs taking over joyful shores. They prefer to have some autonomy over the tech. - Retaining some autonomy to override the system can risk some expected long-term benefits—e.g., reduce energy consumption. - Ground-up smart home can guarantee benefits but limits alterations in the house following life moments. Besides, building a house with a centralised smart system is expensive. - Incremental technology is more accessible and can be installed in old buildings—but software and connection can be issues. Nevertheless, there are hidden costs in cheap and peripheral devices (e.g., exploitative fabrication, waste). - Multiple connection protocols and service providers can be a breach for hacking and privacy. Decentralised controls are a challenge to make things simple to operate—requires more skills from users. - What is superfluous for one person, can be essential for someone else. For instance, assistive smart technology. - Domestic tasks and the kitchen space associated with women, and smart assistants gendered female, resonate problematic gender domestic dynamics.
	Instrumental Values	*SHTs can provide a sense of comfort in the home.* *Prescribing technology because it is efficient.* *Mothers love dishwashers.*	*You don't want to do all the housework, so SHTs can help you bring comfort and convenience.* *Retaining the autonomy to override the SHTs and being able to decide when to automate can also provide comfort.* *Mothers would love a smart washing machine.*	*SHTs are programmed for your convenience, comfort, and satisfaction.* *I don't want my house to be controlled by a device and do everything on my behalf: "Give me something to do!"* *Female voice assistants are not obeying: "she has a mind of her own!"*	
	Adoption Strategies	*Should be a house designed ground-up to be "smart".* *Centralised controls, everything must be built-in and work together.* *Adapting the use of peripheral SHTs to your needs—for purposes different from what they've been designed for. Different priorities in life can affect your adoption of SHTs.* *"Smart" indicates "useful algorithmic control", and some devices are more useful than others—seen as superfluous.* *Some houses don't need automation, especially if you have a small space.* *Kitchens are interesting places for automation.*	*SHTs come up with an answer that you're willing to accept.*	*Technology should be small, cheap to buy, and simple to operate, making it possible for any house to be "smartified" regardless of its external look.* *Using different systems and providers to create resilience—when one of them fail, the other would still be operational. Electronic devices are decentralised, otherwise things can go wrong.* *People don't need smart technology to make their houses better: "If it is a happy place, then it doesn't need much technology."*	
Aesthetics	Typology	*Detached*	*Detached*	*Bungalow*	- Isolated smart homes, with extensive surrounding gardens does not acknowledge urban settlements increasing density. - Unifamilial residences don't account for the diverse ways in which households are constituted.
	Style	*International modernism, functionalism*	*Mid-Century, industrialisation*	*American Craftsman, British Arts and Craft, heritage*	
Experience	References	*Expert decision-making also informed by professionals' experiences as lay-adopters.*	*Empirically acquired expert-like knowledge; 1980s interiors style; pop culture with James Bond and The Jetsons.*	*Interactions with "non-smart" electronic devices; modern brutalist buildings; and pop culture with The Jetsons.*	- Housing is expected to change due to effects of the climate emergency. SHTs will have to respond to these changes. - "Smart" became a buzzword and can deceive consumers. Not all "smart" has AI, and "non-smart" can also be intelligent solutions. - Centralised control restricts adapting devices for alternative uses.
	Ideal Home	*The ideal home must be aligned with your life moment—it might not correspond to the common typology of a smart home.*	*An ideal home needs to have informal meetings spaces to congregate.*	*As we get older, some house typologies might be a problem.*	

Table 4.4 - Table summarising the troubles found between their imaginaires.

Definitions of Smart Home

Generally, all three samples' *imaginaires* associate smart homes and their technologies with advanced digital technology and automation of household tasks. The narrative formulated around the term "smart" is associated with solutionism and technofixes. Professionals and Early-Adopters seem to have their smart home definitions aligned with such an idea, which follows an assumption that analogue or digital technologies could provide services in a more efficient, convenient, and hassle-free way if they were made "smart" by AI. In contrast, Late/Non-Adopters were more reluctant to trust automation, mostly mentioning technologies that are not categorised as "smart" by the current consumer market. Among all three samples, there were also expectations that smart technologies are sustainable and can help with energy savings in the house—not challenging the opaque environmental costs associated with manufacturing and maintenance of the technology.

SHT *imaginaires* contain an overall expectation from samples that smart homes can provide a more comfortable life for their inhabitants. Nevertheless, the way sample groups perceived comfort was associated with distinct instrumental values: for Professionals, comfort is achieved through efficient ambient conditioning; for Early-Adopters comfort emerges through retaining autonomy over smart systems; whilst for Late/Non-Adopters, comfort is associated with the home being resilient to technical faults.

As mentioned in Section 4.1, Early-Adopters' wish to retain autonomy over smart systems and Late/Non-Adopters' diversification of service providers seems to indicate concerns about sensitive information control. This, however, does not characterise an explicit awareness of the privacy, security, and surveillance risks emerging from SHT use. The wish for autonomy and control to override systems can also draw tension with SHTs' sustainable and energy-efficient potentials. If Early-Adopters or Late/Non-Adopters are constantly interfering in the smart energy systems, they might risk the long-term environmental benefits expected. The lack of awareness regarding the impacts of the widespread use of SHTs also regarded how the technology is worsening problematic gender dynamics—among all three samples, some form of sexist comment was made about the domestic use of smart appliances.

While Professionals claimed that smart homes should be designed to be smart, with their technologies integrated at an infrastructural level, Early-Adopter and Late/Non-Adopters displayed a contrasting adoption strategy, with a much more incremental understanding of SHTs. This can be related to the high cost of constructing a house from scratch and the current consumer market of SHTs, which is dominated by peripheral, "plug-and-play" devices.

Smart Homes' Dominant Aesthetic Expression

The dominant aesthetic expression of smart homes is characterised by a modern international modern style, exhibiting functionalist and rationalist ideals closely associated with the industrialisation of domestic life (Cohen, 2012). Professionals have a conventional modernist aesthetic, still connected to Post-War manifestos of housing, machines (Corbusier, 2007), and industrial efficiency. Early-Adopters take the Mid-Century modernist aesthetics to a more playful and isolated smart refuge. Late/Non-Adopters' have opted for an American Craftsman style, with a more conventional house structure to represent their smart home. This choice is related to their wish to have a fully functional home that can cope with technical errors. Another relevant aesthetic point is the similar lack of interaction with the house surroundings. There was no explicit mention of neighbourhoods or city life, the community beyond their smart homes' gardens and backyards—as if the smart home they have designed existed isolated and not in an urban setting.

Experiences Informing SHTs Imaginaires

As participants' individual experiences were expected to emerge from *imaginaires* exploration, Section 4.3 has explored what other references they brought up when imagining smart home technologies. The primary point of contrast here has been the differences between expert decision-making being informed by Professionals' lay-user experiences, and expert-like advice coming from Early-Adopters' DIY or Late/Non-Adopters everyday interaction with multiple electronic devices. Even though the three sample groups had distinct practices and experiences informing their *imaginaire*, they ultimately produced more or less similar results in terms of SHTs definitions. There are some pop culture visual representations of smart homes that were brought up by Early-Adopters and Late/Non-Adopters, like "The Jetsons" and "James Bond". Those visual references served as shortcuts for participants to better describe their *imaginaires*. Previous SHT co-design studies have struggled to incorporate diverse *imaginaires* through a democratic process (Subsection 2.3.1). Recognising the diverse ways in which participants of this research have all been engaging with SHTs as expert partners of their own experiences can indicate a way towards democratising inclusion in co-design.

This preliminary framing of tensions, oppositions, and contestations emerging from the comparative analysis of samples' SHT *imaginaires* was essential to enacting trouble through co-design. The preliminary insights of this subsection were presented to participants as a diagram prompt in Phase 2's workshop [Appendix C, Section 2, (vi) Troubles Diagram]. The next chapter will report on such a workshop, better detailing the co-designed ways in which participants stayed with SHTs troubles.

5. Affecting Imaginaires: Co-Designing Troubles Instead of Solutions

The flat *imaginaires* observed in the previous chapter are both the product and fuel of the solutionism present in how SHTs are currently designed. In one way, the techno-positivism expressed in participants' *imaginaires* validates the development of smart devices simply because they are technically possible (Gram-Hanssen and Darby, 2018; Leitner, 2015). At the same time, the pervasive deployment of AI without a straightforward utility contributes to an *imaginaire* of smart technology as the next "natural" step for industrialised societies (Aldrich, 2003). This chapter will report on the second and third phases of data collection, which explored the potential of co-design in carefully considering the contrasts, oppositions, and tensions surrounding SHT *imaginaires*—instead of finding techno-fixes for poorly framed problems.

Traditionally, design processes are expected to tackle conflicts and propose solutions (Sanders and Stappers, 2008). However, as mentioned in Subsection 2.2.2, theorists have been positioning design practice as a mental model capable of coping with complex problems (Cross, 1982; Schön, 1986). With this paradigm change, design reached audiences outside the expert practice. In the context of this thesis, opening technology design for the inclusion of people historically distanced from it represents a chance to explore design's potential beyond a problem-solving tool. Based on Haraway's call for people to stay with the trouble (2016), I suggest that co-design should be focused on something other than finding technical solutions: it should be focused on better understanding conflicts and revealing tensions in sociotechnical systems. In doing so, co-design can be used to disturb dominant excluding tech discourses, encouraging diverse *imaginaires* to emerge, and, potentially, lead to a fairer development and use of smart technology.

Establishing a list of requirements grounded on society's empowerment over industry profit, participants of this research stayed with SHTs' troubles through co-designing speculative interventions. The foci of such interventions resonate the three main categories of contrasts, oppositions, and tensions elaborated by participants: first, interventions to individual and direct conflicts with devices; then, interventions to regulate the troubled fabrication and consumption process of SHTs; and finally, systemic-focused interventions to people's broader relationship with smart technology. With a multiple focus to stay with different types of troubles, the co-design process provoked reflections that transcended the workshops and meetings, affecting what Professionals, Early-Adopters, and Late/Non-Adopters expected from SHTs and how they came to imagine the technology.

Elaborating on such findings, this chapter is organised into four sections. Section 5.1 presents the requirements negotiated between participants and informing a list of aspects to be prioritised while staying with SHTs' troubles. Section 5.2 then expands on participants' discussions on such troubles—which emerged from their current SHTs *imaginaires* (Chapter 4). Section 5.3 introduces the collection of speculative interventions co-designed by participants as a critical practice of staying with smart technologies. Finally, Section 5.4 argues that in addition to co-design reflective nature providing wider framings for current troubles, such a method can also transform individuals' SHT *imaginaires* towards a more responsible and just future with the technology.

5.1. Co-Designers' Established Priorities

As a collective and open process, it was essential for participants of the co-design to negotiate and establish **priorities** on how they wanted to critically stay with the SHT's troubles. Like in value-led design methods (de Vries, 2009; Iversen et al., 2012; van de Poel, 2015), the prioritised requirements can guide participants in making decisions and steering their final speculative design to satisfy the same requirements.

Recalling the research design previously presented (Section 3.1), participants were expected to reflect on priorities that varied from personal preferences, passing by societal and economic priorities, to priorities affecting planetary transformations. They took such a decision in reaction to the prompting material described in Subsection 3.3.2. Each group agreed on their list of priorities, which presented implications to the diverse ways participants could choose to stay with SHTs troubles.

While negotiating priorities, the activities of the Phase 2 workshop deliberatively allowed time for the groups to expand their demographic limitations, trying to empathise with external perspectives, critics, and provocations to create broader discussions on smart technologies. Exposing adversarial priorities between Professionals, Early-Adopters, and Late/Non-Adopters leads to a reflective process about individual needs and collective risks. The methods chosen for co-design brought awareness and agency to participants' *imaginaires* of SHTs, revealing the intentions, purposes, and objectives behind the

technology. In fact, this is one of the ways that an inclusive and reflective co-design can affect the existing *imaginaires* that are animating the development and use of smart home technology.

This section will report on the four main overarching themes prioritised by participants: transformations of current interactions with smart technology, encouragement of community building, respect for user sovereignty, and reduction of environmental impact.

5.1.1. Transform the Ways of Being with Smart Technology

With the first priority of transforming the ways of being with smart technology, participants aimed to reduce the use and consumption of smart devices (A7), not only for the accumulation and lack of use (A6) but also for feeling "inundated with data," because "there are just more computers in [their] life everywhere." (P4) For them, "a little bit" of technology can be good and valuable, but the over-accumulation of services and devices is unnecessary. Individuals should avoid accumulating technologies they don't need. Some participants consider it even more dangerous to be "too linked up" (N3) and "fully connected" (N2) to technology.

For participants, some smart technologies have become essential (N2), and an example of how you can't avoid some of them might be the smartphone (N8): a personal device that has become pervasive, with so many different parts of everyday life dependent on them—from the primary communication device to banking device, shopping device, and entertainment device. Yet, participants believe that doesn't mean people should aim to be fully connected with SHTs.

To change the over-accumulation of technology, there is a need to transform the social structures surrounding the development of SHTs. For a transformation that can positively impact future generations (N4), there must be a change in how society operates (N6), encompassing political changes, modifying people's attitudes (N7), and the need for them to care about each other (P4) while developing a more planetary consciousness (P6). Generally, N2 considers a priority to establish a common approach between East, West, North, and South countries, recognising that something must be done. "There needs to be greater unity of purpose and cooperation if we're going to solve the issues." (A6) In summary, this priority acknowledges that the current ways of developing and using SHTs are unsustainable. However, contemporary everyday life depends on digital technology. Participants, then, suggest prioritising a transformation based on the establishment of a collective, cross-cultural approach.

5.1.2. Build Communities, Be Less Selfish

For participants, it's essential that SHTs can guarantee simplicity and ease of use in the house without residents needing to "think too much about things." (N3) Users' comfort and relaxation should also be prioritised in technology development, guaranteeing, for instance, quietness and peaceful spaces (A4). When it comes to the smart home, the possibility of arranging and personalising spaces is essential for them (A2), along with the presence of pets and connection to nature (P5). Such aspects could produce a sense of belonging to the community, which can also provide safety.

The sense of safety contrasts with the current individualist approach to SHT development, which promotes insecurities and a lack of community engagement: "Can people be less selfish?" Asks one participant (P4). From this perspective, "people are motivated individually by particular things for themselves and not for the greater good." (A6) There's a need to increase "humanity's connection to each other." (P1) For instance, N3 suggests that if someone needs an appliance, they could borrow it from neighbours instead of buying one and multiplying the number of unities of the same appliance that will eventually be trashed in a landfill.

Another group of participants believe that one way to transform current SHTs individualist approach could be, for instance, collective discussions on housing needs to guarantee everyone a comfortable and safe home. For them, there is a problem of developers "creating cheap houses to save a couple of pounds" (P6). Transformative policies that can provide enough great housing should be one of the priorities when developing smart home technologies. Generally, the self-interest in people's attitude should be transformed: "The very basis of society is how people cooperate and work together and comes down to individuals. If individuals are selfish, you're not gonna have a good social structure." (N7) In summary, this priority considers that people involved in SHTs development and use need to be less selfish, greedy, and profit-oriented. Smart technology should enable community building instead of separating and isolating people.

5.1.3. Reduce Environmental Impact

When using an electronic device, users often don't realise they might be reinforcing prejudices (A1) or even being part of a production and consumption chain that exploits the labour force and natural resources (A3). As mentioned before, SHTs' environmental impacts can be opaque (Morley et al., 2016; Nyborg and Røpke, 2011)—especially if all adopters see is an aesthetically pleasing and clean device in their homes.

As participants' priority, unsustainable practices of consumption and production should be avoided. For A1, there is a need to avoid buying new devices with the excuse that you're upgrading them to a new model and, consequently, generating unnecessary waste. Mirroring knowledge previously found in literature (Morley et al., 2016), participants have the idea that if you have everything connected to the internet, "you will be using

more energy." (A7) Also, participants want to avoid general emissions associated with pollution inside and outside the smart home (A2, P6). Additionally, participants believed that carbon use (A7) and reliance on fossil fuels (A5) could be reduced by worldwide reforestation, renewable energy, and water saving. Smart technologies should prioritise the reduction of plastic use (A3, A1) and maybe even incentivise more sustainable diets (N8), slowing down industrial farming and agriculture (N1).

An environmentally transformative principle that should also be prioritised is related to open-source technology (Superrr, 2022). Participants believe that people should be allowed to fix and upgrade their devices. It's not about demanding private companies to open their technology (A1) but for research and development knowledge to be made available (A1). Open-source technology can also transform the exploitation of natural resources, as it can bring transparency to the technology production chain. Such priority should be followed by broader social change that incorporates educational practices—as open-source technology's benefits are highly dependent on specific digital skills (A3). In summary, participants prioritised the environment in order to reduce the impacts by transforming the production, consumption, and disposal of SHTs.

5.1.4. Respect User Sovereignty

Smart technologies should allow users to change preferences, profiles, and routines without extra work, with a robust system that respects that the user's digital identity is theirs to define (Superrr, 2022). Prioritising privacy, SHTs should also be able to guarantee safe and comfortable smart homes (N2, A1) and, consequently, allow people to live their everyday lives freely, without external control (P4). Unwanted interruptions and decisions being taken on an individual's behalf, according to participants, are forms of losing personal autonomy for the smart system. Participants "want the technology to do for [them] what [they] want it to do." (A4) And, in the case of tech doing things for them, "they want to be in control." (P5) The lack of user autonomy and forms of surveillance and monitoring can be associated to a weak privacy policy.

Current smart homes depend on data tracking, so the algorithms powering devices can recognise patterns and infer actions to be performed by the system. Companies rely on data harvesting to provide householders with digital services, and for that, they expect users to keep their devices constantly producing data on standby. For instance, if you have a smart meter to save energy, the device can generate extra energy consumption as companies "want you to let it on, so then they can monitor things. And then they can use [the data]." (A7) As highlighted by A3, a significant part of this data processing is done in external and third-party data centres. As a priority, future production of SHTs should avoid data tracking and data being used by third parties, with more control for users to decide what to do with their data (A3), avoiding it being used in unanticipated ways.

As a trade-off for adopting smart services and appliances, people may be exposed to some sort of surveillance. Participants were interested in avoiding external control and invasive technology (P5, N1, N2, A7). Invasion of privacy, cameras and microphones constantly recording data, and forms of abusive technology (N2) can risk users' autonomy over the system—another aspect that participants wanted to avoid. Due to the impact on the technical conception of devices, such privacy by default (Superrr, 2022) also implicates new forms of sociability around SHTs. In summary, respecting user sovereignty involves conceding, by default, autonomy for SHT adopters to repair, modify, and personalise their technologies in a hassle-free way without compromising their security and privacy.

5.1.5. In Summary: Promote Healing and Empowerment Instead of Growth

This section has introduced the themes prioritised by participants, a grounding step framing their process of staying with the troubles surrounding SHTs. Participants had a strong understanding that a transformation of the current ways of being with smart technology should be prioritised. Additionally, instead of devices distancing individuals and building a sense of pervasive surveillance, smart technology should prioritise user sovereignty over personal data. Participants also believe that a stronger privacy commitment can support safer community interactions. Finally, prioritising transparency in the smart tech production chain can reveal the environmental trade-offs associated with the consumption of electronic devices.

Participants have acknowledged that such priorities depend on a broader social change, as the current industry still follows a growth development paradigm with economic objectives (A4, N6). A social transformation can directly impact the means of production, redirecting its focus to education and communication between individuals (N7) instead of informing machines and algorithms about user preferences. I.e., a development and use of SHTs that prioritises healing and empowerment over economic growth.

Inspired by the matrix of priorities introduced in Subsection 3.3.2 [Appendix A, Section 8, (iv) Matrix of Priorities], Table 5.1 summarises the thematic quadrants of participants' priorities. Generally, as guiding principles on their way to stay with SHT troubles, participants prioritised the transformation of the ways people currently interact with smart technology, guaranteeing that devices will build communities (instead of relaying people more individualist), avoiding opaque environmental impacts through transparency, while respecting users' privacy and autonomy over smart technologies. This matrix, assembled with the four main aspects prioritised, indicates the collective intention of this research's participants to promote a non-solutionist co-design that promotes healing and empowerment instead of commercial growth.

As a research contribution, the themes approached in this section can provide insights for industry to responsibly build smart devices, inform policymakers on fairer regulatory practices, and encourage individuals to imagine alternative sociotechnical systems. In

the context of this research, the priorities introduced by this section were instrumental in framing the ways participants wanted to stay with the tensions, oppositions, contestations, and resistances surrounding the development and use of SHTs. The following section will elaborate on such SHTs' troubles.

Transform the ways of being with smart technology Acknowledges current smart technology as unsustainable, and proposing a collective, cross-cultural approach.	*Guarantee* community building Instead of isolating people, encourage a less selfish, greedy, and profit oriented sociotechnical system for SHTs.
Avoid environmental impact Reduce impact by transforming the production, consumption, and disposal of SHTs.	*Respect* user sovereignty Autonomy for SHTs adopters to repair, modify, and personalise the technology in a safe and hassle-free way.

Table 5.1 - A matrix of priorities summarising the themes most mentioned by participants as requirements that their co-design should satisfy.

5.2. Staying with SHTs' Troubles

After defining priorities, participants were introduced to a diagram depicting the preliminary analysis of troubles emerging from the comparison of their SHTs *imaginaires* (Subsection 4.4.2). This section advances such preliminary analysis, now further elaborating on the troubles participants have chosen to stay with through their co-design process.

Considering the diverse strategies people employ when adopting smart technologies, it's possible to claim that the perception of SHTs' benefits depends on the adopters' context. Thus, as approached by Chapter 4, the same technology can be associated with various definitions, aesthetics, and everyday experiences, while the comparison of such distinct definitions can depict contrasts, oppositions, and tensions across samples—which, in this research, we have been refereeing to as **troubles** (Haraway, 2016). Instead of rushing to solve the troubles surrounding SHTs, this co-design process proposes staying with them, nourishing contrasting experiences with smart technologies.

The troubles surrounding SHTs' definitions, adoption, and what's expected from them are associated with how different groups imagine the technology. If the industry doesn't engage with the diverse meanings attributed to SHTs, the technology might fail to deliver the promised benefits. Previous SHT co-design studies have tried to build new technology to solve multiple user problems (Bourazeri and Stumpf, 2018; Fitton et al., 2018; Garg and Cui, 2022; Hwang et al., 2012). Instead, based on the experience of this research, I claim that time should be allocated for troubles to be discussed and expanded. In such an

iterative and critical thinking process, people's current relationship with smart technology can be challenged in favour of a more responsible and just way to imagine sociotechnical systems. Thus, initial *imaginaires* were repositioned and affected by participants' critical consciousness of the existing and future impacts of SHTs.

Participants were able to discuss the preliminary framing of the troubles (Subsection 4.4.2), expanding those using their own experiences and examples—in a discursive process of "staying with the trouble" through speculative co-design (more in Section 5.3). When analysing participants' discussions on SHTs troubles, it was possible to cluster them into three main categories: first, (1) product-related troubles in SHTs' functionality; then, (2) regulatory troubles in SHTs production and consumption; and finally, (3) systemic troubles in people's relationship with smart technologies. The three categories of troubles are introduced next.

5.2.1. Product Troubles

Product-related troubles refer to the tensions, contrasts, and oppositions emerging from the direct use of smart home technologies. This involved, but was not limited to, interface and usability matters, technology adoption strategies, and their perceived usefulness.

SHTs Do The Right Thing—If You're Around

Recalling the smart home features presented by Early-Adopters in Phase 1's workshop, it was mentioned that a smart home works around the householders to complement their lifestyle, supposedly performing tasks at the "right time" (Subsection 4.4.2). However, as with any other digitally connected technology, it might present errors, and, additionally, some of these errors might cause devices to wrongly infer an interaction and cause unwanted interruptions in the householder's routine. This was further elaborated during the discussion about troubles in Phase 2, with participants recognising that in such situations, smart home technologies can make their lives "harder" than they should be (P6), giving them "another thing to take care of" (P4) instead of performing the task themselves. "When they don't work, we're not planning for extra time to fix them. It gets frustrating." (N8) The extra work required to make smart technologies perform the automation correctly depends on its users, revealing the limitations of the current technologies.

Another way the system depends on its users, according to participants, is related to smart technologies and online platforms generating new information: "Algorithms can only reproduce stuff that already exists [...] They can't create anything new." (P1) They can "only have what you put in it; they can't change anything." (P4) In the same conversation, participants mentioned being "fussed" about "how humanity is shaping" smart technologies (P1)—as algorithms can be "heavily biased", exacerbating or reinforcing (A6) controversial narratives like conspiracy theories (P4). Those systems

only provide such narratives because you have clicked on a link or shown interest in issues before (P4), and the system interprets it as a user's preference or interest. Following this idea, users share the responsibility of spreading such narratives (A6). Even if they recognise the bias in the training and development of smart technologies, which can effectively lead systems to modify and distort information, participants seem to believe that users (not industry) are responsible for the smart technologies' harmful outcomes, deepening social injustices. This framing of smart technologies follows the calm computing paradigm (Weiser, 1991), implying that devices wait for users to interact with them before responding. This could mislead a conclusion that, without users, there wouldn't be any harmful outcomes from SHTs.

Adoption Depends on Autonomy to Adapt

In Phase 1's workshop, Professionals shared their experience as users of SHT, showing how they have been adapting different components for alternative uses, which were different from their original functionality (Subsection 4.4.2). With this idea of having users adapt the technology to their context (instead of the opposite), in Phase 2's workshop, participants have further elaborated on how smart technologies should not control or dictate how and when they are used (N1).

For participants, adopting SHTs can have many benefits: "They can do the thinking for you so you can enjoy life. But they also might take over joyful chores." (P5) This reinforces an *imaginaire* that home automation is only convenient if it can adapt to users' routines. People don't want devices taking too much from their routine; they want to have "something to do!" (N6) It's possible to understand that adoption is associated with users retaining autonomy over the technology, including when and how they would use it. Technology should allow users to adapt its functions and applications according to their context and routine.

When using smart home technologies, adopters are willing to accept the systems' answers and advice (Subsection 4.4.2). However, Early-Adopters' *imaginaire* highlights the need for them to retain some autonomy to override the system, something that relates to their sense of comfort (Subsection 4.4.2). "Even if they [SHT] might do it better and in more efficient ways," (P5) "we want to retain the autonomy to decide." (A4) This is also connected to the elaboration on systems being flexible enough (A4) to support the unexpected changes in someone's routine instead of being constrained by a limited learning system and user input.

Having the chance to interfere with the system's automatic settings might risk long-term benefits associated with that smart technology. For instance, "if the benefit is financial," and "if you're constantly overriding the system," (N1) "the thing is fragmented," (N7) and you won't be getting cheaper bills because you might be spending electricity in

higher rates—something argued in previous studies (Morley et al., 2016). However, participants "need flexibility," (A4) so systems can cope, for instance, with the fact that they can change their opinion on whether to delegate automation.

Some Smart Technologies Are More Useful Than Others

Echoing statements from Phase 1's workshop, participants believed that smart technology doesn't necessarily make their houses better (N3, N4)—even though acknowledging that, in some cases, smart home technologies present a clear benefit and positive change in adopters' routines. Though individuals might have a clear use for the devices, and they need "a bit of them" (N4), generally, people "don't need smart technology nearly as much." (N3).

From Late/Non-Adopters' understanding in Phase 1's workshop, smart home technologies can electronically do stuff that you might or might not need (Subsection 4.4.2). This has opened discussions in Phase 2's workshop regarding the appropriateness of automation according to users' lifestyles and needs. One participant also referred to smart homes as, in most cases, being "a bit of an indulgence, a bit of a luxury." (A6) Expanding on the ideas of the need for SHTs, there were discussions over the accumulation of devices and electronic gadgets that people can't find a use for. You must find a use for it, and "you need to be selective because if you buy into the whole thing, you're going to be squished [...] It's taking up space." (N3)

While some technologies might present a direct material benefit with "excellent applications" that are "life-changing," (P4) some are considered a luxury, impacting their adoption as people might believe that they don't need smart technologies to make their homes better. For example, P6 challenged the number of commercially available apps that can track your energy data: "I think people have so many gadgets and apps and stuff to track their data, and they don't use any of it; they never look at it." Accordingly, P4 questions the usefulness of a householder knowing the exact temperature of a smart fridge, how much power it's using, and how many times it's open. For them, "Fridges have worked fine for decades. Why do you need this? What values does it have?" (P4) Some participants discussed devices they've acquired but never really found a use for, and they just ended up forgotten somewhere, becoming "stuff". Some smart techs can be a "gimmicky thing, which is like a solution looking for a problem." (P4)

The automation that participants have found more useful is directly associated with adopters' context and routine. For instance, increasing life quality for people living with disabilities. P4 mentioned a friend who is blind and using smart technologies, and they can have more autonomy around the house without asking for another person's help. As A6 is a person living with progressively restricted mobility, having a smart doorbell has been very useful as "It can take [them] a long time to get to the door, so quite often

people will have given up and gone away, whereas now [they] can speak to them through the thing [smart doorbell] and even if they've gone away, at least [they] can look back and see who it was." (A6)

In summary, the product-related troubles elaborated by participants highlighted the unexpected extra work required to fix faulty SHTs, even if they were supposed to reduce householders' workload. Users' constant interference to make technology work properly can then risk long-term benefits associated with SHTs. This places questions on the usefulness of smart technology, which ultimately should respond to users' everyday context needs, not luxury indulgences.

5.2.2. Regulatory Troubles

Regulatory troubles refer to the tensions, contrasts, and oppositions emerging from the governance of smart home technologies production and consumption. This involved, but was not limited to, the opaque environmental costs of producing cheap smart technology and the barriers to repairing and recycling smart electronic devices.

Hidden Costs of Small, Cheap, and Simple Devices

In Phase 1's workshop, Professionals stated that a smart home should be a house designed to be smart, with all its infrastructural systems connected (Subsection 4.4.2) Contrastingly, a Late/Non-Adopter participants stated that smart technology should be "small, cheap, and simple" (N5)—a much more incremental approach to SHT, with "add-on" devices, small in size and cheap in price, easy to use. While discussing this last statement in Phase 2's workshop, participants realised that having "small, cheap, and simple" technology is, in itself, a trouble (A1). Such an incremental approach might present some hidden costs associated with unsustainable manufacturing practices financed by end-users who wish for "things to be cheaper." (A1). Keeping technology simple, small, and cheap can hide a complex network of illegal mining, tax evasion, and human rights breaches.

The cost of advanced research reverted into small-sized smart devices is usually diluted throughout the production chain, with cost savings that can be linked to "the exploitation of people and resources somewhere." (A1) The great majority of consumer electronics currently available in the market have their production and assembly lines in countries that present weak labour rights and favourable tax strategies. Besides, as highlighted by A1, "If you're making it cheap, what materials are you using?"

The clean aspect of a finished and polished smart home technology on the kitchen countertop often blurs this reality. "People don't know that we dig for it." (A1) The hidden troubles of smart home technologies are not exclusive to the production chain. As mentioned in Subsection 2.1.2, it's now known that, for smart devices to personalise

experiences and learn with their users, third-party data centres require constant electricity and tons of purified water to both run processors and cool the generated heat down.

Reuse, Repair, and Recycle—If You Know How

Until recently, most SHTs relied on proprietary software and connection protocols that limited integration between devices from different providers (Basen, 2025). “You can’t ever change the background software. Apple have to work with Apple, and Amazon have to work with their own Amazon system.” (A3) Following the idea that smart home systems can better provide benefits when working together, there is a tension between facilitating connection protocols and dominating a competitive market.

The different brands connected to the internet generate loose ends, exposing the system to potential risks. A household with multiple providers has other connections with third-party data centres and cloud computing infrastructures. An Early-Adopter mentioned their experience in keeping the data collected by their smart home technologies in the house, to be processed by a local server, “so the system will work without connecting to the cloud,” stopping data from being captured by third parties (A3). As remembered by A1, cloud computing is not something simple to understand, which can render some people more vulnerable to data breaches—or harassment from hackers (Paul, 2020). They also mentioned that “things break all the time,” (A1) raising the trouble of what should be done with supposed old or broken technology that becomes electronic waste.

The accumulation of unused technology is associated with how easy it is to purchase a new item or a new version of the same device. For instance, people are usually urged to buy a new phone model periodically, even if their device works perfectly well. For P4, they feel the need to buy a new Kindle eReader every couple of years, even if “[they] don’t need it. There’s nothing wrong with [theirs]. It’s not broken. It still works. It still does the same thing it did all this time.” (P4)

Some companies claim to build their devices with recycled materials (P4), and there’s even the possibility of recovering rare minerals from circuit boards and wires (A6). However, a level of expertise is required for someone to reuse and adapt its smart home systems as A3 did. Additionally, some devices and technologies might be easier to interfere with than others, especially when recycling and repurposing electronic devices. “When you talk about a big telly. Yes, you can repair it, no problem. But when it comes down to like small, more like mobile phones. You can’t repair it.” (A3) When the electronic device is too small and has microscopic technology, almost invisible to the eye, you need to use high technology to fix it, and sometimes, the components can’t afford repairs.

In summary, the regulatory-related troubles elaborated by participants unveiled the hidden cost of current popular, cheap, peripheral smart devices involving illegal mining, tax evasion, and human rights breaches. Additionally, it requires inaccessible

expert knowledge for users to try and repair (or recycle) their devices. The consequent unsustainable consumerism of electronic devices ends up reinforcing the opaque production chain.

5.2.3. Systemic Troubles

Systemic troubles refer to the tensions, contrasts, and oppositions emerging from the broader socio-cultural and economic relationships individuals establish with smart home technologies. This involved, but was not limited to, the reproduction of problematic gender dynamics by smart devices, the uneven distribution of technology benefits, and the unsustainable consumerist values associated with the adoption of smart homes.

The Gender of Smart Technologies

In Phase 1, Professionals' *imaginaires* indicated kitchens as interesting places to automate (Subsection 4.4.2). They usually contain appliances that, if turned into smart, can present "real value" to householders—or at least to the residents who perform tasks in the kitchen. Parallel to this statement, during another Phase 1 workshop, a Late/Non-Adopter complained about their voice assistant not obeying because it has "a mind of her own" (Subsection 4.4.2). The complaint seems to be connected to problematic power hierarchies entrenched in society.

Historically, women have done most of the unpaid household work, from housekeeping chores to cooking and childcare. Sometimes, acting as an assistant to other family members, taking care of groceries, shopping, and planning weekly schedules. As mentioned in Subsection 2.1.2, it's possible to find connections between the social roles historically attributed to women and household automation (Strengers and Kennedy, 2020; Woods, 2021). Until confronted by it in Phase 2's workshop, A6 realised to have never thought about gender in such a context. However, after being introduced to some examples and discussing them with their group, it became "so blindingly obvious" for A6 that household automation can reproduce the unbalanced division of gender roles already present in society.

A form of short-term fix for gendered voice assistants is to make them genderless. From this idea, participants took the chance to expand the trouble towards broadening gender discussions with some contrasting statements. For A2, questioning gender or proposing gender neutrality "causes more problems" because, according to them, "kids [wouldn't] know what a 'true' gender is."—misreferring to gender as biological sex. In addition, they believed that young people now are questioning their genders "as an excuse to be rebellious and a bit different." (A1) As a response, P1 articulated the role of colonialism in socially constructing gender and binarism as natural traits: "lots of countries across the

world have multiple genders, and it was only when colonialism came in, that they ruined it and made it illegal, [...] we think it's normal to have two, but that's not necessarily the right way through." (P1)

As elaborated by participants, this trouble is not a simplistic matter of technically fixing voice interfaces but a prejudice in the *imaginaires* producing/produced by such technologies. As highlighted by P1 in their group, "globally, women still do the vast majority of unpaid labour in the home. Whether or not that's in the kitchen." Even in adverse contexts like the pandemic, A7 mentioned that there has been a "gender bias", or social expectation, for women to perform not only their professional work remotely but also take over unpaid household work. It's not a technical problem to be fixed by some lines of code. It is more related to the human relationship with smart technology, the bias they carry in the software and learning routines: "We need to teach them [people]." (P4)

Tech Benefits are Only for Some

Even if in Phase 2's workshop participants discussed limitations and hidden troubles with smart home technologies, some still believe that "technology can help make everyone's life better." (P6) There are downsides (A4), but those are outweighed by the positive impact on people's reality. For them, "we have to see it in the context that it might do some good things. It'll be lots of bad things as well. But presumably the good things will be appreciated in hindsight." (A4)

Workforce automation during the Industrial Revolution has been largely framed in a liberation *imaginaire* as a means to free society from exhaustive and repetitive work tasks. The same narrative has been explored in household automation: it frees residents' routines from undesirable tasks. Participants compared the Industrial Revolution with the current period, where other niches of everyday life are being automated. For them, such disruptive moments can have a positive long-term impact. "There was a time where just a tonne of people became unemployed, and it was a horrible time for them. But we got through it. And we came out the other side, and things are better now." (P4) Holding to a positivism and techno-fix *imaginaire*, the group stated that having jobs taken by automation would be good "because eventually we just work fewer hours, and we can do more things." (P6) Such troubling statement seems to ignore questions like who can afford to lose their jobs in such a scenario? In the case of a household, what are the things and practices being displaced in favour of automation?

The benefits of smart technologies seem to follow existing socioeconomic divides. "All the things to do with smart technology it's just gated by cost. If you can't afford to buy it, then you're not having it." (P4) In this sense, you'd only experience the technology's benefit if you could pay for it.

Constant Change is Essential

Idealisations around the home theme were prevalent in Phase 1's SHTs *imaginaire*. Because such descriptions of ideal homes present some tensions with the current planetary context, participants further elaborated on the need for a house to respond to its residents' life moments. Professionals affirmed that a smart home should ideally be a house designed ground-up to be smart, with all automation integrated as infrastructures (Subsection 4.4.2). Not many people have the privilege to design their own homes. As discussed in Phase 2's workshop, most of the time, people adapt to an existing structure and make minor modifications (A4). When further discussing such conflicting statements, A4 believes that some representations of the "ideal home" can be "an imperative or external objective that we should aspire to achieve," even if it is a "false objective". They continue: "Whereas we might imagine that there is a perfect smart home out there that would suit everybody in every circumstance, there isn't." (A4)

Recalling the previous experience of hosting people in their houses, N3 challenges representations of smart homes as non-shared spaces. They say the need for shared spaces for different household organisations and foreigners will grow. There has been an increase in the number of immigrants and refugees in multiple parts of the world, and many of those are individuals relocating due to climate change effects. Hence, to imagine smart homes or "ideal homes" as single-family unities seems quite restricted and outdated: "The thing that's often forgotten is that most people are not the only people in the home." (P5) There are different house arrangements sometimes people are only around on specific days of the week, etc.

In summary, the systemic troubles elaborated by participants framed the existing social inequalities being worsened by the widespread use of smart home technologies and how techno-fixes won't dissolve them. For instance, the problematic domestic gender dynamics precede the popularisation of SHTs, and therefore, updating the technology to be less sexist won't necessarily fix the problem. In another example, the desirable benefits associated with SHTs are not the cause of the emerging harmful outcomes. Rather, their relationship regards the poor and unfair distribution of benefits, deepening existing social divides—and systematically ignoring the diverse ways in which households can be composed.

5.2.4. Section Summary

This section has introduced participants' extended elaborations on the preliminary framing of the tensions, oppositions, contestations, and resistances found in the sample groups' SHTs *imaginaires* (Subsection 4.4.2). Those were the troubles that, following groups' established priorities, participants stayed with and speculated on implications (more in Section 5.3).

Troubles were grouped according to their types (product, regulatory, and systemic) to facilitate their presentation and discussion in this thesis. However, it's possible to say that troubled situations can sometimes encompass more than one category. For instance, both gendered smart technology (a systemic trouble) and the environmental impact of small, cheap, and simple devices (a regulatory trouble) have user-interaction implications (a product trouble). Producing non-sexist smart technology would frame new forms of interaction with smart voice assistants, for example. More sustainable technology would require users to preserve their own devices better by repairing and reusing them.

Considering the implications of one type of trouble to another, the three emerging groups of trouble can be said to be co-dependent, highlighting the complex network of tensions, oppositions, contestations, and resistances capable of influencing and worsening overlapping troubles. The three framings of trouble can be seen as a consequence of participants' mature understanding of technological risks, which encourages more responsibility in the way SHTs are currently developed.

Instead of solely relying on the framing generated in my preliminary analysis from Chapter 4, participants expanded their understanding of SHTs' troubles using their experiences and reference examples. With that, they seem to possess the knowledge to foster more critical considerations over technology. As a discursive design practice, this research deliberatively provided an infrastructure to allow participants to ground such considerations into concrete, tactile speculative artefacts. A physical manifestation of technical critique is unlikely to be easily ignored. The following section will introduce such speculative artefacts, which were co-designed with respect to participants' priorities, as a way to stay with SHT troubles.

5.3. Speculative Interventions

In Section 5.1, participants described their priorities for a more responsible and just sociotechnical system with SHTs. Subsequently, in Section 5.2, they further elaborated on the tensions, contrasts, and oppositions producing troubled smart product interactions, poor production and consumption regulation, and systemic undesirable outcomes. In this section, I will introduce the co-designed speculative artefacts encapsulating participants' journey in developing their critical consciousness over SHTs complex network of troubles.

Instead of "solutions" to a problem, the seven speculative artefacts co-designed by participants provoked further elaboration and, consequently, a better understanding of the tensions, oppositions, contestations, and resistances to SHTs. This "designerly" way of staying with the SHT's troubles triggered critical reflections about smart technology's development, use, and impacts, expanding and repositioning previous assumptions regarding the technology's benefits and burdens. In doing so, the speculative artefacts

materialise changes and modifications in the way participants used to imagine the smart home and its technologies (which was characterised in Chapter 4). For this, such artefacts will be referred to as **speculative interventions**.

It was observable that participants' speculative interventions operated with three primary foci, broadly responding to their priorities framework and troubles categories: from (1) speculative products and interfaces to (2) interventions in the electronic devices' production governance and, finally, (3) provocative alternatives for future sociotechnical systems. Participants' designs have a provocative and discursive nature (Dunne and Raby, 2013; Tharp and Tharp, 2022), encouraging discussion rather than providing a straightforward answer. In this section, each speculative intervention will be briefly introduced and illustrated by participant-generated visual data. The interventions have been clustered according to their foci.

5.3.1. Product-Focused Interventions

Product-focused speculative interventions have proposed provocative practices of user interface for smart technologies. Even if participants have indeed designed devices and services, their focus was not on improving a marketable technology but on nudging critical reflections on how current products rely on a passive and pervasive user interaction that benefits the industry with the accumulation of devices and constant surveillance.

Sasha

Triggered by the over-accumulation of devices and online services, meet Sasha. This genderless smart assistant app has been designed by a group of Professionals and Early-Adopters and can help users only purchase or subscribe to truly "useful" things. The intervention in the form of a smart assistant was represented by a fictional advertising poster [Figure 5.1], with three versions of "Sasha" in different coloured sparkly pompoms, highlighting the many forms and identities the assistant comes with—a clear highlight of the current problematic gender dynamics being reinforced by SHTs. The examples in the speech bubbles are specific questions that only a smart assistant like Sasha could answer. For instance: "Which smart doorbell got the best review for blind people?" Sasha isn't like existing assistants, notifying users with unrequired interactions. You'd need to deliberatively reach them out through, for example, a browser extension—instead of the troubled relationship with SHTs that generated more work for users.

Participants envisioned that, without mining your data, Sasha could "guide you through the smart tech jungle." (P4) If you're using Sasha, it ranks websites and products according to your needs, preventing "useless" subscriptions and gizmos. It's inevitable to remember that, with the state-of-the-art data processing and recommendation algorithms training smart technology, it would still be necessary for Sasha to retain some sensitive data to infer personalised content—which is ironic, as using more smart technology to face the

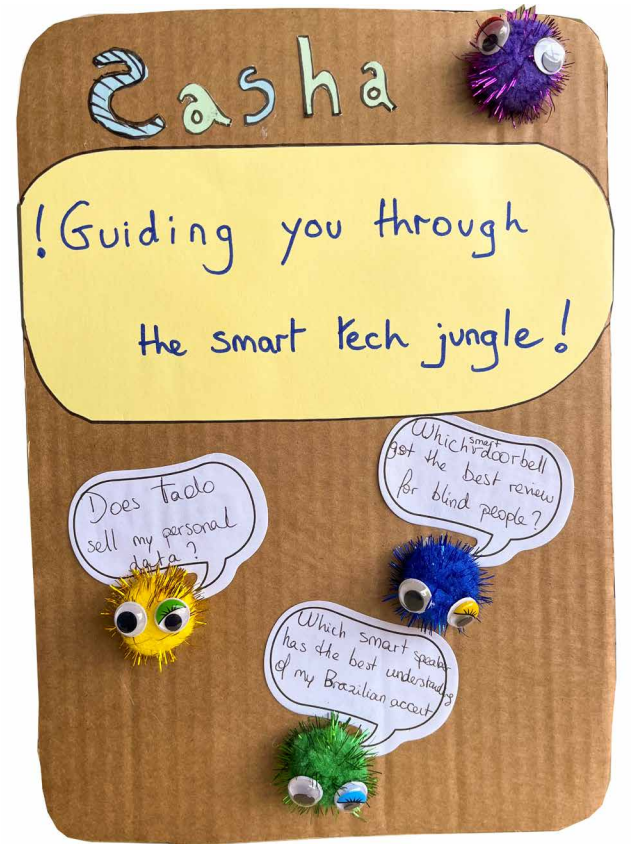


Figure 5.1 - Poster advertising the personal assistant Sasha.

troubles caused by existing smart technologies. Sasha is a not-for-profit service, peer-reviewed, and crowdsourced system with no sponsorship schemes available. The group acknowledged that overusing an app like Sasha could lead people to stop purchasing new devices—which, consequently, would produce major sociotechnical and economic change.

In summary, Sasha stays with the troubled usefulness of smart technology, prioritising the transformation of the industry's individualist approach to technology (currently rendering selfish users). The genderless smart assistant also guarantees freedom for users to focus on the technology they like and need, avoiding a market-pushed overaccumulation of devices. Sasha respects that smart technology should empower users instead of promoting the industry's profit maximisation. With Sasha, it's possible to imagine a sociotechnical system with users empowered by useful and critical information.

Now You See Me

The data extraction and surveillance concerns have made this group of Late/Non-Adopters design a physical interface to control when devices capture users' data. They've detailed this intervention using a household security camera with a lid: when closed, it indicates that the device is not recording users; when opened, users give their consent for their data to be captured. Laptops with a built-in slide lid hiding a standby webcam are not a novelty in the market and seem to have inspired this speculative intervention.

Figure 5.2 - The representation of the camera lid from the project Now You See Me.

Neither is new the inventive ways people have been sticking and capping their webcams to avoid video hacking. However, smart home devices are, indeed, constantly recording to respond to users promptly. Even if it is not clearly stated by the company selling it, this security threat is, in fact, part of most SHTs powered by algorithmic training methods (e.g., big data used in machine learning).

The group represented the camera interface and remote control with a cardboard mock-up [Figure 5.2]. A googly eye represents the camera lens as a focal point, and speech bubbles indicate the interaction with the device. To highlight that the device is not recording when the lid is closed, the group used an eye with its eyelid halfway down—as in "eyes closing" can't see. Making "it explicit that they are seeing you or not," (N1) comes from the group's intention of users maintaining control over what devices track and how they use your data. The mock-up critically invites the audience to reflect on privacy and surveillance concerning smart home technologies, as well as users' autonomy in deciding when not to provide their data.

It's important to acknowledge the limitations of a physical interface when it comes to accessibility for people with reduced mobility. Nonetheless, having physical control over data capture requires users to have low informatic skills, making it a potential option for late adopters of SHTs. There's a further opportunity for Now You See Me to not only make data capturing visible but also make the captured data available and intelligible, providing more transparency. The awareness of data tracking and ownership from

this intervention has led participants to consider this kind of physical interface as an "educational tool" (N7), making it visible what users are trading off with industry to access certain technologies.

In summary, Now You See Me stays with the troubled relationship between users' autonomy and technological control. It promotes a user-interface change that leads to further transformations in the current opaque control of information by industry. This physical interface guarantees that smart devices will be used to connect people through information sharing, education, and learning. Providing users with the power to control how their data is used, avoiding surveillance and respecting users' privacy as a default priority. With Now You See Me, it's possible to imagine a sociotechnical system where users have full autonomy to control automation, not the other way around.

5.3.2. Regulatory-Focused Interventions

The second group of speculative interventions regards designs that are interested in the regulation and governance of smart home technologies. As such, this group of interventions provoke reflections on current unsustainable consumption practices through shading light at the often masqueraded exploitative and harmful production chains.

International Organization

This group of Late/Non-Adopters has designed a fictional poster advertising the works of an International Organisation that regulates the production of smart technologies, particularly regarding the initial stages when sourcing materials. It is an institution that oversees labour conditions and natural resources exploitation, implementing policies to guarantee human rights and more responsibility in mining. This intervention departs from the group's statement that "we are going to have to accept some smart technology," because "they are being imposed on us by various nationwide organisations." (N3) Hence, there is a need to regulate their production. According to the group, policies from an international organisation are helpful as they can have a long-term impact on people's behaviour. In assessing possible risks, the group believed that "bad actors" could use their power in the organisation to hide predatory and exploitative practices within the technology production chain.

The visual representation of the poster [Figure 5.3] is composed of prompt questions written in speech bubbles and arranged like a dialogue, talking about the exploitation of natural resources by the electronics industry. The background colour yellow has been used as a call for attention. At the same time, the grass texture on the top and bottom of the poster refers to the organisation's positive environmental impact. The advertising aimed to raise awareness among consumers of cheap, small and simple smart technologies, revealing the exploitations occurring in the technology production chain.

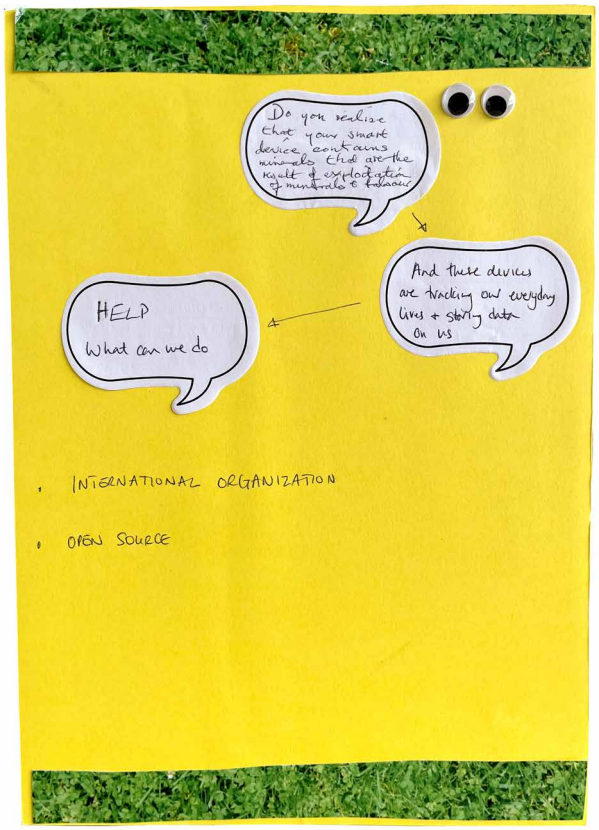


Figure 5.3 - Picture of a fictional poster advertising the International Organization.

Regulatory technology bodies are common and require reliable political articulation with private sectors. Yet, they tend to focus on the governance of marketing and fabrication standards, which can be easily manipulated considering the size of contemporary production chains. Representatives from local communities and conservation groups are essential in the intervention, along with the international regulatory level between member states. Incorporating vulnerable voices can be challenging for the International Org, as abstract politics might discourage people after long hours of work.

In summary, the International Organisation stays with the troubled infrastructure behind the development of smart connected devices. Their focus is transforming the current opaque and unsafe exploitation of natural resources, prioritising individual reconnection with the environment and avoiding data tracking. The organisation also advocates for open-source initiatives. With the International Organisation, it's possible to imagine a more sustainable sociotechnical system.

Open-Source Policy

This group of Early-Adopters has designed an Open-Source Policy manifesto, considering the dichotomy of current cheap and easy-to-use smart technology: broad access to technology by underprivileged populations due to lower prices versus the actual cost

Figure 5.4 - The fictional poster advertising the disparities between labour exploitation and technology consumers' suburbs.

that often hides the exploitation of other vulnerable populations. Similar to the previous International Organisation, the policy brings more transparency by depicting the conditions in which smart technology is produced.

The intervention was illustrated by a fictional advertising poster [Figure 5.4], showing two sides of the same reality: the first, on the right, is a wealthy suburb neighbourhood with new houses, green gardens, and topiary trees. The left part represents a mining scene with a young figure reading about a new policy that might protect them against labour exploitation. The image intends to generate reflection and raise awareness about the labour conditions in the consumer electronics market. Still, it's a distant and comfortable way to look at labour exploitation and is not necessarily effective in provoking change. Instead, perhaps allowing exploited communities to tell their own stories and raise legal claims can be more transformative.

The group believed that demanding transparency through open-source technology can make consumers more aware of the exploitations in the production chain and potentially empower them to reuse and recycle devices instead of purchasing new versions—acting to reduce smart technology's hidden environmental costs. Although the group didn't detail how the open-source policy would be implemented, there is an exciting focus on tackling the trouble in its source, to the scale of production and consumption—instead

of an intervention that transfers the responsibility of acting up to individuals affected. Consumers have access to hardware and software, overriding, updating, and modifying smart devices according to their needs, encouraging people not to throw away "obsolete" products and reducing electronic waste. In terms of impacts, for instance, participants highlighted that the energy sector could better deploy energy-saving programmes as they would have access to protocols in SHTs connected to the distribution grid. Nevertheless, an open-source policy demands further transformation in a liberal market and industrial competition.

In summary, the Open-Source Policy stays with the trouble of producing small, cheap and simple smart home technologies. The policy wants to transform the excess of electronic waste from unsustainable production and consumption practices. Thus, open-source technology guarantees benefits for users without the industry retaining control over data. With the Open-Source Policy, it's possible to imagine a sociotechnical system where individuals understand how their smart technology has been produced.

5.3.3. Systemic-Focused Interventions

The third and last group of speculative interventions are focused on a systemic change in how the public interacts with technology in general. The provocations here come from the utopic (and some dystopic) tones found in the scenarios describing alternative sociotechnical systems.

Back to Nature Communities

To reduce carbon emissions, a group of Professionals and Early-Adopters envisioned a housing development project where the community agrees to switch off their devices and appliances simultaneously. The carbon emissions associated with household electricity would drop, with people being encouraged to pursue collective outdoor activities, like gardening. The community is "off-grid", relying on the latest energy generation technology with solar panels, wind turbines, heat pumps, and an outdoor gym to power the houses. Even if the project speculates on a systemic level, it is expected to interfere in the fabrication and consumption of smart technologies to support an alternative energy routine.

This intervention triggers a reflection on which social groups have the choice of switching off electricity. There are many examples of existing communities that need to ration their use of energy resources as they might not have a reliable connection to distribution grids—e.g., islanders, riverine communities, and forest settlements. In some ways, their isolation is deepened by the lack of public infrastructure and a weak state presence. Such communities are unable to adapt their routine by choice, like in the Back to Nature project, which is part of the systemic trouble of SHTs providing benefits for an already privileged few.

Figure 5.5 - A detail of the diorama representing the Back to Nature Communities.

Participants represented their speculative intervention in a diorama depicting people outside their homes [Figure 5.5]. With electronic devices switched off, they're busy gardening and interacting with each other. The focal point is placed in the centre placard announcing the community's name and advertising that people who go live there can "reconnect" to nature. The diorama creates a utopian narrative for off-grid communities with positivity and humbleness represented through green grass and clay bricks.

The group recognised some crucial limitations, like overloading the energy infrastructure of the settlement when switching everything back on (N7). Here, using smart energy technologies is essential to managing peaks and voltages. Also crucial is the need to involve external stakeholders—e.g., householders' employers, as they need to agree on alternative work shifts. On the opportunities side, thinking about low- and high-energy events would be possible, as well as centralising tasks like cooking in a communal kitchen (P5). A likely outcome of this intervention is the redundancy of some resource distribution industries, like gas and energy infrastructure.

In summary, the Back to Nature Communities stay with the constant troubled changes of a household that follows residents' life moments. These communities transform the long-term impacts of having an ideal home by lowering their carbon usage by going off-grid. In doing so, local environments can be protected by residents' ongoing "offline" interactions instead of relying on technological surveillance to keep the community safe. With Back to Nature Communities, it's possible to imagine sociotechnical systems where smart homes are not isolated entities.

Lifetime Ration Book

The trouble of a house constantly changing with its householders is in the use of natural resources, production of construction waste, and increased consumption of new devices replacing obsolete electronic devices. A group composed of Professionals and Early-Adopters designed an intervention to continue allowing household material changes that follow someone's life while making it more sustainable. People receive a Lifetime Ration Book with resource usage tokens, from rare minerals to water and artificial polymers.

The group visually represented the intervention with a mock-up-coloured book. Each colour represents a different category of tokens, like orange CO2 allowance [Figure 5.6]. Having a physical copy of the Lifetime Ration Book is thought-provoking, as people could flip around and wonder how they would use each limited resource. The group intended rations to be primarily applied to purchasing new smart technologies, forcing the industry to adapt and stop producing new models of supposedly outdated devices. Instead, they offer technologies "that would augment and work well with what you already had." (P5) If smart homes need to evolve with users, more open and transparent house infrastructures need to allow residents to interfere and modify their home systems without depending on proprietary technology.

People can iteratively improve "their own individual environment within these constraints" (A4) so they can only use so much energy, battery power, minerals, etc. Like the Back to Nature Communities, the Ration Book impacts sociotechnical systems. The availability of natural resources would be fairer distributed instead of conditioned to an individual's capacity to pay for extra amounts. It would make individuals carefully consider their priorities when modifying their homes. The group believed this policy-like intervention would encourage people to reuse, recycle, exchange, and even pool their tokens to acquire more significant resources. Participants expecting residents to be more inventive by restricting their use of resources seem to place the wages of the construction impacts in individual actions while the industry's power remains unchallenged.

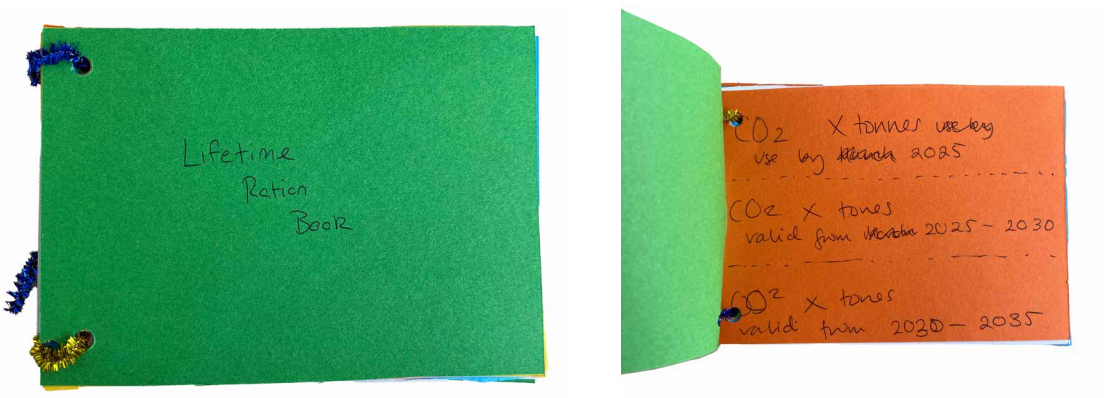


Figure 5.6 - The Lifetime Ration Book cover and first page depicting CO2 tokens.

In summary, the Lifetime Ration Book stays with the troubled search for an ideal home based on resource-intense improvements. The rations can transform the current state of housing, providing a fairer distribution of resources. In doing so, the ration book guarantees that people can improve their personal spaces, tailoring them to their individualities (e.g., life moment, age, time availability, etc.) and avoiding external impositions. With the Lifetime Ration Book, it's possible to imagine the diverse and inventive ways in which individuals would constitute their sociotechnical systems without consumerism and natural resources exploitation.

No More Stuff Wall

Positioned between a strategy and a principle on "how future things should be", a group of Late/Non-Adopters proposed a speculative intervention in the way new devices and technologies are manufactured: the implementation of a global prohibition on industrial production. People are incentivised to reuse, repair, and lend things they own, supported by a sharing and exchange local economy—a potentially fairer distribution of benefits associated with technology use.

The group believed the prohibition could also result in people growing, crafting, and farming for their subsistence. It's important to acknowledge that people living in current low-industrialized territories already produce and grow their goods in local subsistence economies, constantly adapting to build resilience. This scenario sometimes comes from the historical exploitation of vulnerable territories by rich countries looking for natural resources to power their industrialisation. There is a risk that speculative design like the No More Stuff Wall romanticises the absence of a production market by choice. However, the group intended to highlight a lifestyle reconnected with the means of production, fomenting people's autonomy over smart technologies and awareness of resource scarcity.

The group represented the intervention with a diorama illustrating a fictional routine of people living under such prohibition [Figure 5.7]. As an anticipated outcome, the scene shows community interaction, with people talking to each other, asking or offering help, and working in a small collective garden. The main element of the diorama, which also happens to be the focal point, is a monumental stone wall where "No More Stuff" is written, marking the limits of prohibition of production. In such an "extreme scenario," (N2) progress is not associated with technological advancements but rather with the environmental benefits of production interruption. The group classified their systemic-focused intervention as "people-oriented" and "anti-technology," still recognising its limitations—for instance, the impacts on healthcare.

In summary, the No More Stuff Wall stays with the troubled assumption that people don't need smart technologies to improve their household lives. The provocative production prohibition transforms the current consumerist lifestyle into a subsistence lifestyle. This would guarantee safety and comfort through interpersonal interaction instead of

Figure 5.7 - The No More Stuff Wall diorama depicts a routine in the life of people living under the production prohibition.

through invasive technology surveillance. With the No More Stuff Wall, it's possible to see how disruptive and dystopic answers to the alarming effects of SHT production and consumption are not difficult to imagine.

5.3.4. Section Summary

This section has presented the speculative interventions co-designed by participants to stay with the troubles surrounding SHTs. It is possible to say that the interventions designed by groups of Professionals and Early-Adopters present a slightly more positive take on smart technologies when compared to the ones designed by Late/Non-Adopters—who raised more concerns over transparency, privacy, and consumption. A common characteristic across all speculative interventions was the required involvement of more than one group of actors or stakeholders distributed at different levels of governance and regulation. Making it clear that more responsible and just SHTs requires collective and systematic organisation.

Beyond the profiles of the samples composing each group, the speculative interventions provoked reflection around three main themes: first, product and usability designs, like Now You See Me and Sasha, modify devices to interfere with the industry's and consumers' relationship. More information and transparency would be provided so people could make informed decisions about using or purchasing SHTs.

A second type is associated with interventions that regulate production and consumption, tackling the sources of troubles in SHTs—e.g., the International Organisation and the Open-Source Policy. Interfering and governing the initial steps of technological production can positively impact the rest of the production chain and device adoption.

The last type seems to be of designed resource scarcities—e.g., No More Stuff Wall, Back to Nature Communities, and Lifetime Ration Book. Interventions that seem to provoke reflection on transferring the responsibilities for SHT troubles to householders rather than holding powerful stakeholders accountable, like the tech companies actively performing the illegal mineral and labour.

Rather than presenting solutions to open-ended problems, the speculative interventions highlighted dimensions of troubles associated with producing, consuming, and using smart home technologies. Additionally, they provoke reflection on the impacts on the relationship individuals currently establish with technologies. For participants to go beyond techno-fixes, it was essential for them to openly know their priorities and to have a mature, critical understanding of SHTs' troubles. In doing so, the SHT *imaginaires* participants presented at the beginning of this co-design process (Chapter 4) were critically affected by the designerly practice of staying with the trouble.

5.4. Transformative Process

This chapter has demonstrated how co-design methodologies can be used to critically stay with SHTs' troubles, affecting participants' pre-conceptions or idealisations that may have composed their *imaginaires* (Chapter 4). To the best of my knowledge, it's the first time that research on SHTs presents a discursive, speculative co-design procedure, encouraging diverse participants to challenge the troubles surrounding the technology—instead of reinforcing solutionism through traditional top-down research methods (like previous studies introduced in Subsection 2.3.1), participants speculative interventions allowed then to challenge SHTs troubles. In doing so, I demonstrated that co-design holds the potential to transform the current techno-positivist development of smart technologies, promoting more responsible practices in industry and empowering consumers to demand a fairer distribution of technological benefits and burdens. This closing section will argue in favour of co-design as a transformative design practice.

While critically considering SHTs' troubles, Section 5.1 reported on participants' awareness of what they value in their everyday lives—which can be translated into technological requirements. Discussing different stakeholders' priorities is part of the constant empathy building within co-design processes. People can relate to each other and better understand the complementary priorities that can lead to collective efforts in different types and scales, all focusing on a systemic approach. Establishing collective

priorities was not only instrumental to co-design their speculative interventions, but it can also inform industry and policymakers on what future smart home technologies should comply with to support a more responsible and just sociotechnical system.

The imagined interventions introduced in Section 5.3 speculate and provoke alternatives to the constraints of current *imaginaires* behind the development and use of SHTs. A common characteristic across all co-designed interventions was their reliance on a broader social organisation—e.g., a production prohibition of the No More Stuff Wall scale would require cross-sectorial arrangements to collectively transition the industry to an end. Participants were capable of such complex reflections because the co-design was organised around the process' potential in allowing individuals to iteratively generate further understandings about the tensions, oppositions, contestations and resistances surrounding SHTs—the main results of such elaborations were presented in Section 5.2.

This section will first introduce a synthesis illustrating the visual scenario emerging from the speculative intentions on the initial SHT *imaginaires*, showing how this alternative *imaginaire* looks like. Then, I will further elaborate on the understanding that a "trouble-focused" co-design is capable of transforming SHTs in a systemic way.

5.4.1. Visual Synthesis of Affected SHTs Imaginaires

The co-designed interventions speculate on alternatives to the industry's current predatory practices. Such interventions framed the needed transformations as not coming from new devices but from a more transparent production chain, fostering human relationships with less accumulation of devices through sharing and reusing. With the objective of better illustrating how co-design has affected the *imaginaires* behind participants' understandings of SHT development and use, I have synthesised the modifications proposed by each speculative intervention in the design of Figure 5.8.

Chapter 4 has explored visual representations of each sample's SHT *imaginaires*. Now, it's possible to visualise how, if deployed, the interventions of Chapter 5 can alter Chapter 4's SHT *imaginaires*. The illustration [Figure 5.8] represents the following five main transformations being proposed by the speculative interventions:

> 1. Smart Home Communities: Transforming the initial SHT imaginaires of a detached (and isolated) smart home surrounded by gardens, the speculative interventions described community alternatives. Interventions like the Back to Nature Communities describe collective activities like communal kitchens and gardening for when the energy is switched off. The energy efficiency wouldn't necessarily come from a smart management system but from householders' collective action. Thus, in this scenario, instead of relying on smart technologies to do tasks on their behalf, householders have the autonomy to control their smart home—to the extent of switching it off completely. I represented this collective characteristic of the affected SHTs imaginaires by placing the original isolated smart homes

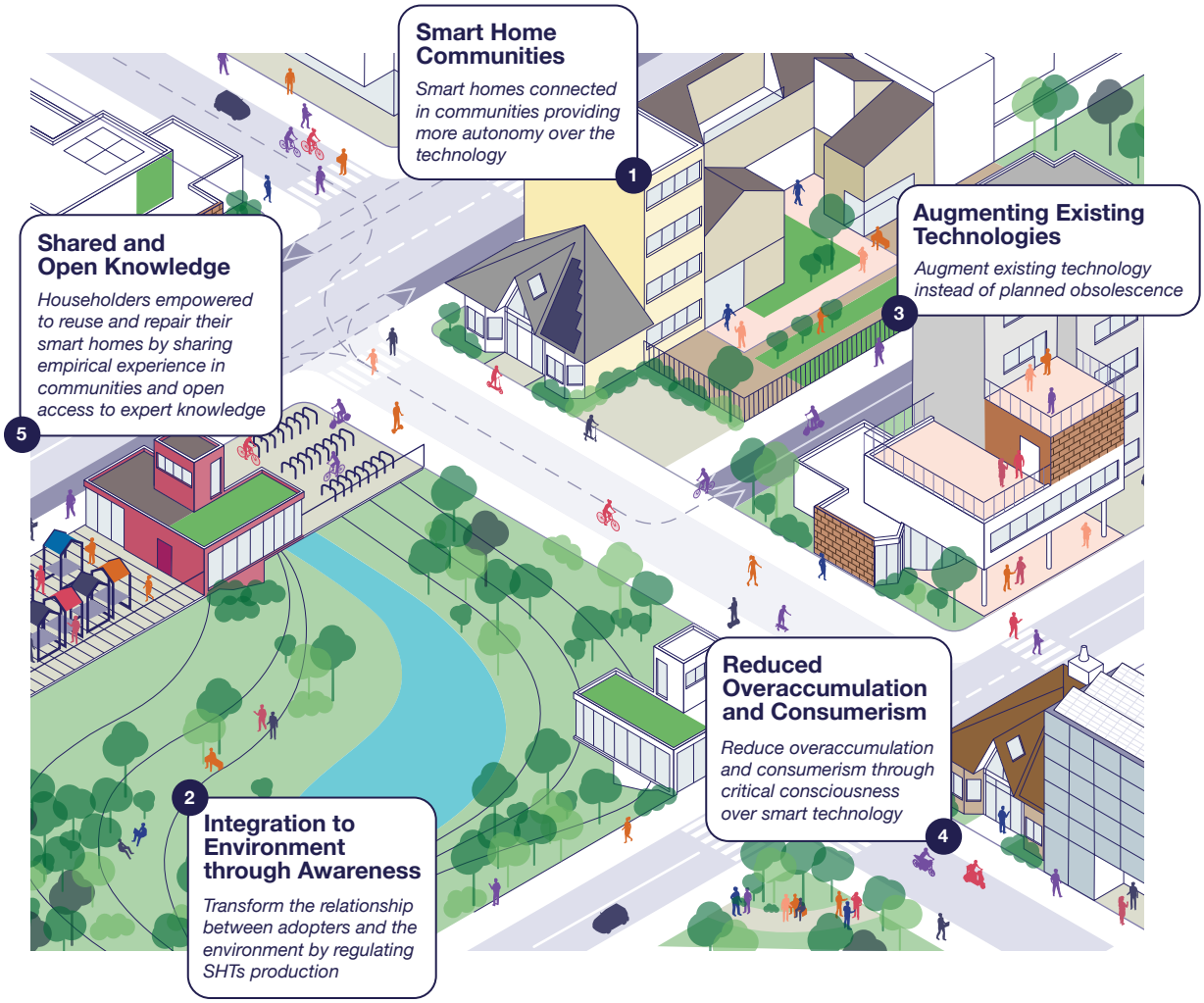


Figure 5.8 - Visual interpretation of each intervention's effects in the imaginaire of the three isolated smart homes.

designed by Professionals, Early-Adopters, and Late/Non-Adopters (Chapter 4) in the dense context of a neighbourhood. Participants also believe that interventions like the Lifetime Ration Book and the No More Stuff Wall can encourage a sharing and exchange local economy, resulting in more community interactions. Instead of a consumption culture, this imagined society is transitioning to a scenario of less technology, and the remaining devices have a clear, practical, and collective benefit. In such an imagined community of smart homes, pervasive electronic surveillance is made redundant by a sense of security coming from locals' engagement. Instead of surveillance, the perceived safety increase resulted from knowing your community. Additionally, because of the integration with other household's energy routines, carbon reliance would be collectively reduced—this was represented by active mobility and a reduced number of private cars.

2. Integration to Environment through Awareness: In this alternative and speculative imaginaire, the integration of smart homes with nature won't come from framing the outdoors with wide windows (like in the initial smart homes in Chapter 4) but through the awareness of natural resources exploitation by industry.

This transparency in the production of SHTs has been mentioned by interventions like the International Organisation and the Open-Source Policy. However, a more provocative smart assistant like Sasha is also able to disclose how the electronic devices composing a smart home were manufactured. Some restrictions on the consumption and exploitation of natural resources might seem like constraints in today's economic model. Still, they enable more conscious reflection as one would need to be inventive instead of solving minor everyday life issues by purchasing a new smart product. Therefore, it is not about admiring a privately owned landscape from inside a smart home but about transforming the relationship between adopters and the environment by regulating SHT production. I represented the preservation of the environment and more responsible and just exploitation of natural resources with people inhabiting green parks and with a river crossing the neighbourhood of smart homes.

3. Augmenting Existing Technologies: Instead of homes designed to be smart, the scenario speculates on an incremental and phased adoption of technology. As the Late/Non-Adopters' SHTs imaginaire anticipated, smart homes then have a miscellaneous of technologies, not only "smart" ones. With interventions like the Lifetime Ration Book and the No More Stuff Wall, people start adapting to a fairer distribution of resources when building their homes and private spaces. I represented these incremental changes by interfering in the initial all-white and modern design of participants' smart homes. The smart homes' modifications follow householders' life moments, thus meaning that unanticipated changes can happen, and participial retrofits might be executed using alternative construction materials. Smart homes start fashioning a patchwork of materials and finishings, marking the passage of time with extensions and apparent fixes. Instead of following a modern and decontextualised aesthetic, smart homes use local resources in a much more eclectic and organic style—potentially closer to what was initially imagined by Late/Non-Adopters (Chapter 4). This is also connected to householders' autonomy to change and enhance their technology as it is open source. This characteristic speculates on the industry adapting to a DIY demand, launching assets that can augment existing technological resources instead of pushing through new devices following planned obsolescence. When possible, components could be recycled to be used in other devices. In terms of strategies for technology adoption, the affected imaginaires are much more aligned with incremental SHTs, with diverse service providers and manufacturing companies providing resilient smart homes.

4. Reduced Overaccumulation and Consumerism: Householders' critical consciousness over electronic devices manufacturing have affected their imaginaire. Thus, the imagined scenario doesn't describe the overaccumulation of electronic devices. Instead, adopters are able to look for SHTs that are useful for their routine. For instance, interventions such as Sasha actively modify Professionals' SHTs imaginaire heavily dependent on full automation (Chapter 4). The scepticism

presented in Late/Non-Adopters' initial SHTs imaginaire is useful in encouraging a more critical consumption of electronic devices. Instead of rushing to adopt smart technologies, people can check what is truly useful for them. As product-focused interventions require a household level of detail, I have preferred to represent the critical consciousness using billboards depicting Sasha and the Now You See Me interventions. Furthermore, the fact that the neighbourhood was illustrated without any overaccumulation of waste is also connected to this imagined form of critical consumption.

5. Shared and Open Knowledge: Multiple instances of open knowledge support the previous characteristics of this alternative SHT imaginaire. From industrial transparency with the Open-Source Policy to sharing and exchanging products in the No More Stuff Wall, knowledge builds people's capacity to reuse and repair smart devices, electronic components, and their building resources. This goes in a different direction from proprietary technology, which segregates professional expertise from adopters' empirical experience and expectations. Instead of relying on pop culture representations of smart homes, adopters and non-adopters are encouraged to develop practical knowledge of smart technology as per the new strategies of technology adoption. Critical consciousness over the opaque impacts of SHTs on the environment and social inequalities can emerge from knowledge sharing in the collective engagement in smart home communities. Open knowledge is expanded to other niches like house renovations, influencing how homes evolve with their householders' lives. In this imagined alternative sociotechnical system, companies then make it easier for people to follow their production chain and carbon footprints. The whole operation and production of electronic devices is registered, verifiable, and overseen to prevent labour or illegal practices of natural resource exploitation. I represented this responsible and just distribution of knowledge through a community share and exchange fair. Tools, warehouses, and other infrastructure are shared between local communities, enhancing social interactions.

The five characteristics are a non-exhaustive exploration of alternatives for more responsible and just smart technologies. In the imagined scenario, such characteristics co-exist and are co-dependent, participating in a system of change. Through the speculative interventions, this chapter demonstrated co-design potential in troubling sociotechnical systems. Once disturbed, alternative *imaginaires* can take place, broadening diversity representation in technology development and challenging unfair power dynamics. In doing so, it's possible to imagine and systematise ways to stay with the complexities of SHTs.

5.4.2. Systemic Through Different Scales

An overall realisation emerging from participants was placing "staying with troubles" as an ongoing practice, as "there's always going to be trouble." (N6) A troubled reality is expected because of the speed of the current technology industry and the crescent impacts of global challenges. This sophisticated understanding of troubles also came from participants' recognition of co-design as an open practice that experiments with temporary solutions with the aim of finding suitable answers—not a silver bullet (more of this in Chapter 6).

This chapter argued from the beginning that troubles are not something that should be tamed or prevented. They provide diversity. They can nudge people to reflect beyond limited definitions, accessing different meanings of the same situation. Troubles are both the fuel and the product for a transformative co-design: fuel in the sense that design methodologies are deployed in relation to troubled situations and product in the potential of speculative co-design in disturbing established unfair sociotechnical systems.

The three foci common to the findings in the co-designed speculative interventions, the troubles discussions, and the requirements prioritised by groups resemble participants' multidimensional profiles and social backgrounds. Interventions like SASHA and Now You See Me satisfy usability priorities while staying with functionality troubles that directly affect people who adopt SHTs. Interventions such as the International Organisation and the Open-Source Policy regulate the industry while staying with production troubles, directly affecting how its professionals develop SHTs. Finally, utopic interventions like the Back to Nature Communities, Lifetime Ration Book, and the No More Stuff Wall speculate on alternative human-technology interactions while staying with a troubled sociotechnical system affecting even non-adopters of SHTs.

Smart home technology *imaginaires* can be affected by practices that acknowledge the diverse ways in which people connect to and conceptualise their artefacts. With a focus on revealing characteristics of complex, open, wicked problems, co-design enables such transformative practices towards a more responsible and just way to stay with SHTs. The purpose of a co-design shouldn't be enforcing change in someone's technological perception but an opportunity to encounter other dissonant opinions. Acknowledging the existence of "the other", participants of a co-design expand their references—and, only then, potentially inform changes in their relationship with technology. Infrastructure individual awareness is an essential part of systemic transformations. By allowing reflections on diverse groups of troubles using multiple foci of speculative artefacts, this co-design enabled systemic transformations. The following chapter will elaborate on the characteristics enabling such transformative potential.

6. Challenging Imaginaires: Evaluating Co-Design Transformative Potential

While Chapters 4 and 5 have analysed the results produced by the co-design process, I take a step back to evaluate the process itself in this chapter. Besides reporting on insights from the feedback forms and Phase 4's evaluative interviews, reflections will also incorporate my experience as a researcher in running the study. In doing so, this chapter aims to present practices for a more responsible and just participation in SHT research and design.

Co-design has been described in the literature as a process that, relying on design tools, researchers/designers share decision-making power with active participants, who then steer a mutual learning process with their social values (Sanders and Stappers, 2008; Simonsen and Robertson, 2012; van den Hoven et al., 2015). Those are not only generic characteristics of co-design but also opportunities to challenge traditional design hierarchies. Yet, for the process to be socially transformative and generate sociotechnical change, it needs to empower participants beyond the role of research subjects or informants played in previous participation methods.

Different methods and frameworks for designing technology with users have been described before. The general expectation is that, in methods like co-design, inclusion can lead to more responsible research and innovation practices and, in some cases, leverage a fairer distribution of decision-making power. However, responsibility and justice are not inherent to co-design—they're a positionality that must be clearly stated. The unfair power dynamics present in the traditional development of technology will be maintained if broader social structures around SHTs remain unchallenged (Cruz, 2017; Feenberg, 2002). Based on the research insights presented in this chapter, I claim that structural change can be incorporated in co-design if the process has diverse participants informing

decision-makers, counting on a revamped participation infrastructure that aims for mutual learning instead of product improvement, resulting in participants empowerment to challenge structures maintaining an irresponsible and unfair sociotechnical system.

This chapter is then organised into four sections. Section 6.1 will first discuss the power dynamics encompassing the co-design process and the role of diverse inclusion in opening smart technology design to historically excluded groups. Then, Section 6.2 will highlight the importance of a participation infrastructure in revamping the relationship between professionals and adopters of smart technology. After that, Section 6.3 introduces what was learned from a co-design that prioritises participant empowerment over product improvement. The chapter concludes with Section 6.4, understanding that co-design can enable more responsible and just SHTs if it systematically informs decision-makers through a revamped learning process that challenges the dominant *imaginaires* behind technology development—leading to broader structural changes.

6.1. Balancing Power Dynamics

> "Interact with your end-user, who isn't a tech head, who is just a person living their life at home, feels like the only way you can get things right, isn't it?" (A1)

Contrasting traditional design, co-design can split open design practice in favour of participation. People from different backgrounds can express their values, needs, and boundaries, democratically pursuing collective objectives through an open conversation. Nevertheless, co-design must be intentionally organised with fairer inner power dynamics—otherwise, it risks reproducing social inequalities external to the process.

Some forms of inclusion in technology design can render participants as research subjects in a hierarchical process that prioritises product development over people's empowerment (Subsection 2.3.1). Even if such forms of inclusion can still relay considerable gains in informing how to improve technology, the distribution of benefits and burdens will follow today's unequal access to digital technology.

Co-design participants bring their social privileges and vulnerabilities, which influence how they engage and assume leading roles in co-design. Responsible and just power arrangements within co-design are not guaranteed. They are intentional and subject to constant reaffirmation. This section argues that such active movement to balance power dynamics in co-design can start before the process itself, with recruitment. The section then shows how power balance can be manifested throughout the process in negotiating common objectives and establishing a group dynamic open to diverse people to participate, bringing their different perspectives.

6.1.1. The Importance of Diversifying Inclusion

As remarked by a participant in the co-design process: "You can't move forward in a smart world and leave half the world behind." (A1) This claim seems to follow an idea that if a smart technology future is there for everyone, *everyone* must be included in its design. With an increasing demand for advanced technological solutions to tackle global challenges (e.g., the climate crisis), it's essential that industry and academia include as many people as possible in their discussions (Section 2.2).

With the objective of diversifying the inclusion in co-design, participants of this research were selected according to their diverse experiences with SHTs. As described in the recruiting strategy (Section 3.2), three groups were profiled: professionals developing SHTs, early adopters of the technology, and late or non-adopters. The diverse panel of participants were recognised in the process evaluation as an opportunity to "engage with a real diversity of people and allow everybody to actually productively input" (P5). Additionally, P6 considered the process inclusive because they were trying to co-design things "thinking of different types of people," who were not necessarily present in the meetings.

Nevertheless, when reflecting on the process's diversity, A4 believed that people involved represented only a "small subsection of society [...] who is [already] interested in technology." This reflection comes from participants' acknowledgement of their own socio-economic privileges and calls for recruitment practices that account for further characteristics framing social and political agency (N5, N4), such as neurodiversity, diverse economic backgrounds, gender and sexual orientation diversity, racial diversity, and others.

As participants reflected, co-design opens an opportunity for people involved to represent those historically excluded (A1, N3)—being it because of their social or economic backgrounds, expertise, technology adoption, etc. The prefix "co-" indicates a collective action in co-design (Sanders and Stappers, 2008). Hence, participation is expected and essential. However, inclusion is not a procedural fix enacted by bringing more numbers of people (Pallett et al., 2024). Robust diversity strategies must be brought for inclusion in technology design to generate more responsibility and social justice.

When evaluating their participation, A2 highlighted that inclusion can assist tech development in targeting what consumers need or expect in terms of functionalities and features—instead of designing "things [that] might not be important to those people [using it]." The same participant stated that people should be included as early as possible before a finished product is launched. A product that has been "discussed with a sort of universal group," is "going to be taken on by more people because it's going to do more of what they want." (A2) Then, the most apparent risk of not pursuing some form of participation is, according to A2, of industry launching products that don't meet users' expectations.

As A1 reflected in the case of SHTs, they have been developed mainly by "white cisgender male" professionals. A technology guided by a limited group of *imaginaires* can fail to distribute benefits to other social groups—or even neglect their negative impacts on vulnerable communities. Therefore, with diverse perspectives, it is possible, for instance, to avoid bias associated with a limited pool of design references. Diversifying inclusion is not necessarily about changing participants' belief systems but allowing contrasting realities to meet, starting dialogues, and setting common goals between oppositions.

There are well-established benefits associated with the inclusion of users in technology development. As previously mentioned in Section 2.2, inclusion is a fundamental aspect of RRI frameworks. People taking part in research and innovation projects have the chance to place their views and needs in discussion, representing the interests of their demographic group and expanding the project's risk assessment and impact mitigation capabilities (Stahl and Coeckelbergh, 2016).

In summary, the co-design study has shown that a deliberative, diverse recruitment strategy is essential to reach vulnerable social groups, who, historically, have been systematically denied a platform to raise their claims. In doing so, the co-design of SHTs will better represent diverse *imaginaires*, informing a more responsible and just distribution of technological benefits and risks.

6.1.2. Developing Common Objectives

When evaluating the current study, P5 reported keeping their mind open due to the initial uncertainties of the process, while N2 mentioned taking a position of going "with the flow," as participants didn't know "what the end would be." (N4) The initial moments of uncertainty described by participants seems to be connected with the fact that co-design should be co-led by the people taking part in it (Kensing and Greenbaum, 2013; Sanders and Stappers, 2008). With that, the initial aims of the process are open enough to allow participants to develop a common objective. Aligned expectations and common objectivities ground subsequent collaborations, essential aspects of a co-design process that aims to challenge uneven power dynamics.

As highlighted by N1 over the process, if, in the first meetings, they had been told that "smart technology should help [them] all and make things easier," they would have faithfully believed without questioning or challenging the statement. The general point of having a common objective is related to aligned expectations between stakeholders without hidden agendas. Everyone involved in co-design is conscious and has agreed to work together to pursue common goals. In the co-design process, this characteristic was mostly noticed in two moments: first, in Phase 1's workshop, the definition of the smart home remained open until participants composed one together (Chapter 4); and, in a second moment, in Phase 2's workshop, groups of participants openly negotiated the priorities they had followed on their way to stay with SHTs troubles (Chapter 5).

Even with initial objectives being kept open, participants of this research have been able to describe the broader themes approached during the workshops. When recalling such themes, they've mentioned "future" and "digital age", "sustainability" and "environmental crisis", adding the responsibility of "making sure that people aren't forgotten," (A1) in the design of "smart tech" and "smart home".

It's possible to link the uncertain initial goals of this co-design with the "designerly way" of problem-solving described in Section 2.4: Designers generate temporary solution proposals to better frame the open problems being tackled (Dorst and Cross, 2001). When transposed to the co-design process, this "designerly way" of problem-solving requires participants to cope with some uncertainty regarding objectives. Therefore, a sentiment of temporary loss is expected when people involved demonstrate different capacities to cope with the unexpected. I argue here that participants were fully aware of the themes being discussed, and their temporary uncertainties on what the end of the process would be were somewhat related to the discursive nature of the methods used (Tharp and Tharp, 2022), not a lack of objective.

Additionally, people taking part in this research first met during the workshops. Instead of recruiting a self-organised group with previously established objectives, this research congregated individuals with a shared interest in smart technologies. It was essential to acknowledge that participants were not pursuing a common objective from the start. Instead of a constraint, the process took advantage of the contrasting perspectives individuals brought in. For example, in Phase 1 of data collection, the exploration and comparison of SHT *imaginaires* was only possible because participants presented different profiles (reported in Chapter 4). While the existing integration in a self-organised group is relevant for them to achieve their objective, the potential of a dispersed sample relies on the rich contrasts between participants' backgrounds and positionalities. They see the co-design process from a different perspective. They each relate to various aspects of the study instead of having a single, unidimensional take on the objectives.

Co-design's shared decision-making (Kensing and Greenbaum, 2013; Sanders and Stappers, 2008) positions participants as accountable partners, equally responsible for establishing objectives. However, using the example of the results in Chapter 4, the flat *imaginaires* can reveal that individuals taking part in the co-design study might have got used to top-down approaches—where they assume a "subject" position instead of being empowered as active partners. In this way, there seems to be further opportunities for participants to be included in the organisation of methods and meetings, advancing their role as partners.

In summary, in a co-design process, it is essential for people involved to share a common goal. For a more responsible and just co-design of SHTs, objectives should not be enforced and hidden but collectively discussed, agreed upon, and transparent for everyone involved. Considering that this research deliberatively allocated time for participants to talk through and generate objectives common to the group.

6.1.3. Democratic Group Dynamics

The diverse roles participants have taken in this co-design study responded to their experiences and skills, from writing and presenting as a "spokesperson," (A2) to crafting and making decisions (A4). Inevitably, the dynamics encompassing this co-design practice also responded to people's personalities. For instance, one participant claimed not having problems in expressing themselves (P6), while others considered themselves "not the one who talks." (N3) It's possible to claim, then, that people's personal histories and personalities are [pre]determinant characteristics in any participation strategy and can influence on how they democratically take part in research—even if this means they won't take an active role.

The meetings and activities in this research were organised with an adaptable structure, incorporating the constant change of positions and types of collaboration between different personalities. For instance, the methodological procedures of Phase 2's workshop comprehended and alternated between individual activities, group activities, and collective activities with all participants together (Subsection 3.3.2). Some participants reported that opportunities to work individually and in groups felt balanced, with "time allotted to everything," (A6) making "enough space for everybody to have input." (N1) This dynamic has allowed for collaboration without a fixed leader or dominant personality (N1, N7), even if some participants were not used to teamwork (A7).

As mentioned in Subsection 2.2.2, in a co-design process, researchers are expected to assume alternative roles, attempting to step away from the position of leading facilitators and mediators in favour of a partner role (Kensing and Greenbaum, 2013; Sanders and Stappers, 2008). With that, participants can engage in an open dynamic that allows them to move roles, sometimes leading conversations and making decisions.

This aspect was highlighted by participants of the co-design study, mentioning that the process "was the right environment to speak up and be listened to," (N1) because it was a non-judgmental, safe space to do it (N2) without being "closed down by anybody." (N4) Instead of "participation to influence" others, co-design can give equal opportunities for people to be listened to (A7) while sharing the responsibility for the ideas being put forward (N6). Such group dynamics are expected to be democratic in how diverse (and adverse) *imaginaires* of SHTs can co-exist—instead of the totalitarianism of a single, dominant perspective. Co-design's transformative potential doesn't rely on forcing an alignment of participants' views but on disturbing rigid representations of technology.

In summary, having an open group dynamic can grant space for common objectives to be explored between diverse participants, making people feel safe enough to take action, challenge opinions, and propose something new. I claim that establishing such democratic, open conversation in co-design is essential to achieve a more horizontal power distribution.

6.1.4. Section Summary

The diagram in Figure 6.1 summarises the three main themes this section has touched upon. Those are essential characteristics to balance the power dynamics encompassing a co-design process. First, existing social inequalities are expected to make their way into co-design as the process aims to **diversify inclusion** [Figure 6.1], bringing people from different backgrounds to take part in research. Including such diverse and sometimes adverse perspectives should not reinforce such inequalities but establish an alternative structure that blurs dominant discourses, allowing alternative ideas to flourish.

Secondly, even if participants have had different reasons or interests in participating, they should pursue agreed **common objectives** [Figure 6.1]. In the case of this thesis' co-design, clearly stating and constantly reaffirming the aim to produce more just SHTs held the potential for the process to render just outcomes. Thirdly, aligning expectations is also essential for an open and transparent discussion in co-design, delineating a democratic **group dynamic** [Figure 6.1]. Participants then share the power to decide and the responsibilities for the ideas and discourses they put forward.

It was possible to observe in this section that in smart technology development, the democratic participation of professionals, adopters, and non-adopters can better inform decision-makers of their technological needs and expectations. Consequently, this can potentially lead to more responsible and just ways to cope with the troubles surrounding SHTs. Yet, as previously stated, inclusion is not a procedural fix for technology (Pallett et

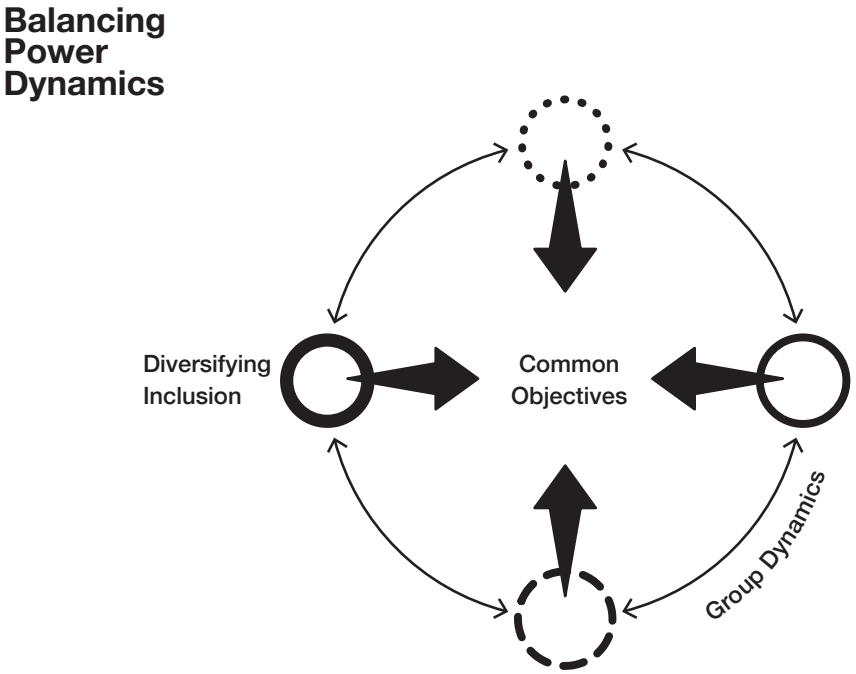


Figure 6.1 - Diagram summarising how a diversified inclusion of different social groups by the circles can agree on focusing on common objectives while establishing an open and democratic group dynamic.

al., 2024), and alone cannot challenge dominant *imaginaires* behind the development of the technology. Based on the experience of running the study, I suggest that a further step for co-design to get closer to its transformative potential is to thoroughly consider its participation infrastructure, turning abstract concepts tactile through design methods, thus making it accessible for the diverse individuals taking part in the research—as the next section will elaborate on.

6.2. Democratising The Participation Infrastructure

> "It felt like you'd done quite a lot of work in between, so we were always building on the previous step." (P5)

Any research study presents a physical infrastructure—e.g., spaces, communication pieces, images, etc.—and a meta-physical infrastructure—e.g., methods, theories, facilitation techniques, etc. For instance, this co-design study required enough physical space for people to convey while being mediated by specific design methodologies to facilitate participants staying with the troubles surrounding SHTs. This section will argue that an open conversation between a diverse group of individuals with a balanced power distribution is influenced by its surroundings, i.e., a more responsible and just co-design is subject to the available infrastructures.

Co-design infrastructures influence the way people participate. Not only does it open the research and innovation for participants' input in a conscious, direct way, but also—like in the case of *imaginaires* (Chapter 4)—it can allow individuals' subjectivities to emerge. In contrast, a rigid infrastructure can constrain people's engagement and confine them to specific participating roles—such as "research subjects" or informants. In Chapter 5, providing an adaptative infrastructure was essential for participants to immerse themselves in a reflective practice, trial and error imagined speculative interventions to highlight and challenge the troubles surrounding SHTs.

This section will first elaborate on the potential of visual representations to give form to abstract ideas, easing communication between participants while helping them to discuss possible implications of the things being co-designed. It will then mark the relevance of sensory and tactile methods in enhancing stakeholders' design capabilities. After that, it will argue that an enjoyable and ludic participation infrastructure contributes to keeping participants engaged.

6.2.1. Visual Representations as Cognitive Support

When reflecting on the co-designed smart homes from Phase 1 (Chapter 4), N1 described that visual representations were more effective in bringing up people's ideas about technology "than just talking about it, making a bullet point list of things." In

this participatory research, visual representations seem to have improved rapport between participants, making ideas clearer and enabling further collaborations. This finding seems to resonate with the deliberative take on visual methods as a structural part of framework definitions, participants' interactions, results analysis, and insights documentation (as described in Chapter 3).

The visual representations were capable of revealing aspects participants were unaware of: "It's only when you look at what other people have done," that you realise what you are missing (A2). In that sense, during the study, "having pictures, rather than just talking," becomes an aid to formulate a plan and work on it (N4). Essentially, participants were able to "see" what others were thinking, which "would have been quite difficult to do without something [visual] to focus on." (A6)

The expression and analysis of participants' SHT *imaginaires* in Chapter 4, for instance, were only possible because of the visual methods employed. About that, P5 reflected those visuals "highlighted whether [participants] had different mental images of what the idea was," with the "physical manifestation of it" showing the contrasts, helping them make collective decisions. Even if composed of imagery and textual metaphors, Wunenburger (2020) has defended the importance of images in keeping open the subjective structures of the *imaginaire*—allowing its mutable dynamic through which individuals input meanings to things and ideas (Chapter 2). In doing so, the visual expression of people's *imaginaire* seems to not only present a still image of their current perception of a subject but can also trigger further reflections now that such an excerpt of *imaginaire* can be analysed from the outside.

Considering the context of the speculative interventions from Phase 2's workshop (Chapter 5), N6 saw the visual representations and models crafted as making ideas a reality subject to testing so that unintended consequences could be kept out (A1) and benefits better distributed (N2). With the use of appropriate documentation strategies, what once was abstract imagery has been made actionable. When it comes to participatory methods composing responsible research and innovation frameworks (or RRI, presented in Section 2.2), the research verifiability relies precisely on its impact on deliberation capacity. It's possible to assume, then, that co-design can enable a more tactile form of responsibility when relying on visual representation to discuss the benefits and risks of a technological project.

As mentioned in Section 3.4, visual methods hold the potential to go beyond their illustrative role (Brown and Collins, 2021). Due to the efficacy of visual communication, visual representations can be deployed as cognitive support, providing a better understanding of theoretical discussion, processes, and generated outcomes—as part of the designerly ways of knowing, thinking, and acting (Cross, 1982).

Co-design methods are based on creative, systemic thinking, visual expression, and any other elements found in design. Such elements are usually transposed to the context of the people taking part in co-design. Previous Section 2.2 highlighted the singular ways in which designers think and approach a creative task (Cross, 2006, 1982). For instance, developing a visual iconographic vocabulary and using it to create new images and representations are characteristics of designers' practice. Therefore, co-design is expected to deploy activities and tasks that take advantage of such visual vocabulary—from sticky note diagrams to crafting models and prototypes (Chapter 5).

A small group of participants in this research found it difficult to express themselves in a graphic way (A4, N1), even if they consider themselves "a very visual person." (N5) Besides the potential and effectiveness of visual representations, images seem to be conditioned to an individual's experiences and skills. The reported lack of fluency with visual representation can also be an effect of previous forms of inclusion that have constrained participation to verbal and textual expressions—focusing on facilitating the extraction of information instead of empowering individuals as co-producers of their sociotechnical systems. As claimed at the end of Chapter 4, participants' SHT *imaginaires* seem to be standardised by a common, external, dominant narrative of technology positivism. Instead of encouraging individuals to challenge *imaginaires*, the identified flat *imaginaire* renders individuals as passive observers. Visual representation shouldn't be discredited by its subjective nature but positioned as a possible key to untangling troubled *imaginaires*.

In summary, the use of visual representation during the co-design study revealed that images and artefacts can not only communicate ideas but serve as cognitive support to generate them. Additionally, the lack of fluency with graphic representation reported by some participants might have resulted from the combination of previous anti-democratic forms of inclusion and participants' flat *imaginaires* (Subsection 4.4.1).

6.2.2. Abstract Made Tactile Through Sensory Methods

When reflecting on their participation in the co-design study, A1 defined it as a "mindful, whole-body" experience that allowed them to go into different parts of their brain "to look for answers," instead of "a dry 'sit around and do a mind map'." This experience describes a creative process that is activated by the sensory methods deliberatively employed in this research. Sensory methods like the blindfolding in Phase 1's workshops condition a reorganisation of an individual's senses, allowing them to be fully present in design activities.

For N7, the co-design workshops were also helpful in placing abstract concepts into a practical context. That was evident in Chapter 5 when social values were made "concrete" through the requirements prioritised by participants and grounded in speculative interventions (Section 5.3). This characteristic resembles values-led design practices (van de Poel, 2015), where social values become features in the things being designed.

Participants claimed that they had never come across a way of working like the one used in this co-design research (A1, A2, A7, N5). Their lack of familiarity with the methods caused suspicion in some (N3). Considering the position taken towards using co-design to disturb and challenge SHTs' *imaginaires*, the discomfort felt by participants during activities was another form of staying with the trouble (Haraway, 2016).

The tension rising from experiencing sensory methods in co-design was connected to participants' apparent solutionist expectations of technology design: "I like working on a focus. I have got a problem to solve, I find ways to solve the problem." (N7) An open-ended, sensory co-design can sound counterintuitive in the face of a prevalent smart technology *imaginaire* associated with efficiency and solution. However, the "chaos" and "discomfort" described by participants (N2) are essential to challenge stable sociotechnical systems that keep reinforcing social inequalities, widening pervasive surveillance, and increasing environmental impact.

Traditional participatory research and even previous co-design studies seem to overlook manual and "hands-on" methods to benefit from more established and conventional qualitative research methods. However, based on the evidence collected in the current research, I argue that considered naïve practices like arts and crafts can reduce the distance between external public and science research. Visual representations associated with prioritising a bodily experience over rational and formal knowledge offer participants of co-design the possibility (and confidence) of grounding engagement in their everyday life expertise. Responsibility and justice, for instance, could be made "concrete" through images and crafted objects—a material manifestation of impacts is more difficult to ignore while fostering accountability.

In summary, sensory methods were an essential step for participants who did not present professional training in design. Parallel to visual representation turning ideas into reality, sensory methods rendered tactile participants' social values encapsulated in artefacts, such as the speculative interventions (Section 5.3). This approach to co-design can encourage more responsible and just outcomes as the physical manifestation of technological risks is not easily discarded.

6.2.3. Engagement Can't be Neglected

Even if participants are able to recognise the relevance of volunteering for research (A2) and the need to "build bridges" between industry and users (A6), they all have personal demands in their everyday lives (N3, N4). Keeping participants actively contributing can be as challenging as an initial recruitment process.

In the current research study, P5 recognised that people could participate because even if co-design was challenging, it was not "asking things that people couldn't give." Once participants had attended meetings, there was an intention to balance workshop aims and what was possible to produce in the available time, respecting that they were volunteers who wanted to contribute even if they didn't have any professional or teamwork experience.

In Phase 3 of the co-design study, participants experienced an online focus group. Afterwards, when reflecting on the online meetings, participants positioned such interaction as the meeting they remembered the least (A4, P5, P6). They've reported a lack of confidence and being hard to engage or collaborate in the video call (A2, A6), claiming that a "sit down," (N1) "face-to-face" (A7) Phase 3 could have been better—even if the online interaction made possible people from different locations to meet (N4). For A2, the ubiquity of online qualitative data collection seems to lack the physical experience of an in-person meeting and keeps participants more isolated from each other.

Remote engagement can make meetings, interviews, and workshops accessible for people experiencing permanent or temporary travel restrictions, like social isolation due to the COVID-19 outbreak. Additionally, hybrid or remote work schemes are everywhere in technology development, consolidating a more distant and disembodied moment for the industry. Considering participants' evaluation of the focus group and the experience of facilitating it, it's possible to claim that an online, virtual participation infrastructure seems to condition participants to be less engaging and collaborative—after all, dropouts are one button away in a video call. A challenging and, sometimes, uncomfortable co-design process that aims to stay with troubles instead of finding easy solutions can benefit from an in-person participation infrastructure that adapts to participants' needs.

From a "pleasant" time (A4) that "didn't feel like work," (N3) to constant "stimulation" (A6) and "fun" (N2), the majority of participants that evaluated the co-design study claimed that their interest in engaging in the research also depended on how they felt during the meetings: "If there hadn't been as relaxed as it had been, I don't think as many people would have stayed." (A2) Those are less quantifiable aspects of engagement that can't be guaranteed through methods. However, due to the importance given by participants to their enjoyment during the study, I suggest that a participation infrastructure should not overlook the ludic and performative characteristics of its methods and facilitation strategies.

In summary, participatory research depends on the constant engagement of the external public to enact its transformative potential. Thus, co-design should account for playful and engaging methods capable of keeping participants motivated and interested. Still, participation infrastructures must also account for the expected dropouts and be flexible enough to accommodate participants' needs.

6.2.4. Section Summary

This section has explored how the balanced distribution of decision-making power in co-design is influenced by its surrounding participation infrastructure. Here, I have highlighted that a co-design process relies not only on the physical infrastructure of its meetings but also on the meta-physical one when referring to participants' subjectivities Chapter 4).

The diagram in Figure 6.2 summarises the three main ways in which this co-design study has enacted an accessible and open participation infrastructure. The visual nature of design methods employed in participatory research can go beyond the role of communication means and serve as a cognitive support for discussions, making abstract concepts more intelligible through **visual representation** [Figure 6.2]. Along with visual representation, **sensory methods** [Figure 6.2] can enable participants to access their subjectivities when

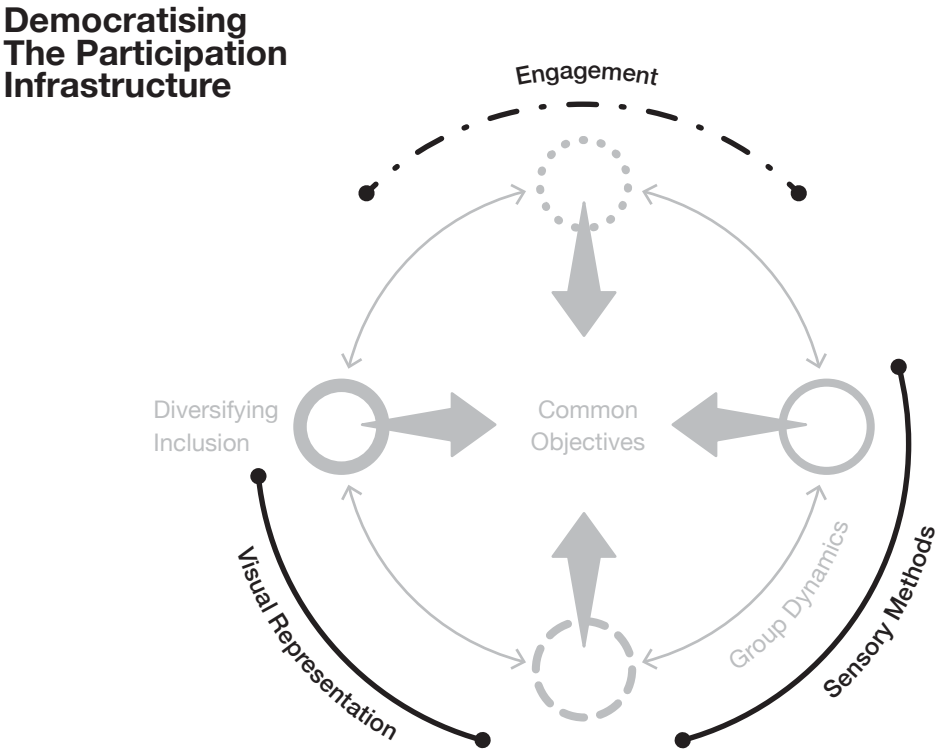


Figure 6.2 - Diagram summarising the position of visual representation and sensory methods to compose a participation infrastructure that allows more flexible and permeable forms of engagement.

collaborating and empathising with peers. Combined, visual and sensory methods can provide participants with tools to turn their everyday social values into tactile artefacts. Even though **engagement** [Figure 6.2] is not constant, the participation infrastructure can be flexible enough to respect people's availability and volunteer affiliation with the research.

As mentioned in Subsection 2.1.2, the industry's solutionism and techno-fixes seem to be conditioning the irresponsibilities in the current design of smart home technologies. The inclusion of external publics in today's technology development is mostly done through user-centred methods (Subsection 2.3.1), with a restricting infrastructure that positions participants as subjects. This chapter has reported on the non-solutionist and accessible methodological procedures composing this research's co-design process. I claim that, together with a balanced power dynamic, an open and accessible participation infrastructure can revamp stakeholders' relationships, bridging what has been previously referred to as the gap between industry and users (Leitner, 2015). Yet, for co-design to continue to advance towards a more responsible and just development practice, I suggest that considerable attention should be given to the purpose and intentions of the process. The next section introduces the claim that the co-design of SHTs should prioritise mutual learning over product improvement.

6.3. Mutual Learning Instead of Product Improvement

> "We've all got ideas inside of us or a little knowledge about what we would like from smart technologies." (N6)

One of the most essential aspects of co-design is the mutual learning environment that it can establish. People involved bring knowledge based on their everyday lives or professional expertise (Iversen et al., 2012; Steen, 2013). Such knowledge is shared with peers through organic interactions and completed with structured information provided by organisers or researchers. Learning from this contact between types of expertise depends on the participation infrastructure as well as on participants' openness and empathy towards other realities and opinions. In the case of the current study, such learning involved raising awareness about smart technology's risks, triggering critical reflections on their use and development. This section will argue the possibility of participants threading an empowerment route over SHTs, relying on co-design capacity to support a learning process.

If a balanced power dynamic has been maintained within an open and liberating participation infrastructure, participants can have enough autonomy to explore each other's knowledge and experiences, dedicating time to reflect on troubles and make new connections and correlations. Participants' empowerment should not be taken for granted; instead, it should be figured out as an intention of co-design.

Co-design is transformative not only for the people participating in it—possibly influencing their belief systems—but also for the researchers organising it, who are responsible for systematising and disseminating the knowledge generated through the process. For instance, after the current co-design study, Early and Late/Non-Adopters of SHTs are equipped to raise their concerns, democratically demanding a shift in the development and regulation of smart technologies, bringing more responsible and just practices to effectively challenge dominant sociotechnical systems. From Professionals' perspective, they have experienced a transformative, democratic, and accessible method that can be replicated in their professional practice to encourage more responsible and just outcomes.

This section will first elaborate on the previous knowledge both participants and organisers carried into the co-design process. The second part will focus on participants' learning journey, from awareness to critical thinking and potentially feeling empowered to disseminate their insights. Still, on learning, the third part of the section presents three main themes for co-design practitioners to learn from: the inherent responsibility of researchers and designers, the public's autonomy to participate, and the need to acknowledge the potential of existing practices.

6.3.1. Previous Knowledge Brought by Participants

As acknowledged by N6 in the case of the co-design study, all participants have "got a level of experience of living in this life," and they, more or less, have clear "how [they] want to go forward and what [they] want." The knowledge they bring expresses their experiences with the studied subject in their everyday life. They constitute assumptions, expectations, and *imaginaire*. Participants demonstrated everyday life expertise with smart technology-related topics: A2 analysed how electricity consumption in the UK is lower than in 2015, even with more devices connected to the distribution grids. At the same time, A7 argued about their poor user interface experience after needing to allocate time and resources to learn how to operate supposed "intuitive" new devices. Even if participants didn't bring structured specific knowledge from their interactions with smart technologies, they've unconsciously informed their SHT *imaginaires*.

Another manifestation of the knowledge constituted by participants' previous interactions with SHTs was their technology positionality. Where individuals positioned themselves in relation to smart technology has influenced their engagement with the topic and their level of criticism when designing speculative interventions in Chapter 5: "It's a matter of your personal philosophy." (N5) In general, Early-Adopters that took part in the current study thought of SHTs as positive things (A2), especially if you live with disabilities such as a progressive reduced mobility (A6). Contrastingly, Late/Non-Adopters believe that smart technologies cause more issues than help, demanding a learning curve that not everyone is available to pursue (N3). Additionally, there was a strong statement that SHTs can render users "lazy" (N2, N5), and some prefer to "get off [their] a** and close

the curtain rather than telling a machine to do it." (N7) Between extremes, Professionals taking part in the study evaluated that most participants "weren't particularly anti-technology," but they also didn't believe "that you needed to put technology everywhere," (P5) as in if controlled, smart home technologies are "only beneficial." (P6)

Participants' technology positionality seems to resonate with the characteristics expected from their sampling profiles, which brought contrasting knowledge to negotiate and collaborate during the co-design process. Existing knowledge and *imaginaires*, however, are not fixed or rigid, and individuals' contact with new references and representations can inform changes through a learning journey—like the process of affecting SHT *imaginaires* in Phase 2's workshop, reported in Chapter 5.

Regardless of their professional training, participants have positionalities and relatable empirical experiences that can be used to establish new correlations in co-designing new knowledge. It was essential to recognise participants' existing knowledge in this research, allowing those to emerge during activities and influencing how they perceived or engaged with new information from their peers. As described in design justice literature (Costanza-Chock, 2020), respecting the existing tacit knowledge from people involved in co-design can enact more fairness than imposing a formal practice often alien to participants.

In summary, participants are expected to arrive for co-design with pre-conceptions over the focused theme. Instead of trying to change preconceptions, the process needs to position them as experts in their everyday lives. Thus, they are capable of sharing their expertise with others. Mutual learning starts from this moment of sharing the teaching responsibilities among co-design partners.

6.3.2. Participants' Learning Process

For participants, taking part in the co-design study prevented them from having a "tunnel vision." (A2) Before, they had thought about smart technology impacts in an "insular" way: "only how it would affect [them], in [their] home." (N4) Co-design focused on staying with the troubles of SHTs allowed them to be more **open-minded** (N5), seeing and listening to other people (P5), "thinking broadly about things, instead of having a narrow focus." (A6) Even if changing people's opinions was not part of the process, having access to new structured information and other participants' realities seem to have made people see things differently—as in, after the co-design process, people had been provided with the resources to make better-informed decisions in relation to smart technologies, instead of just pushing them aside (N4).

Practising being open to analysing new information has contributed to what participants explored as **awareness**. Being part of the co-design process was defined as "eye-opening." (A1) Participants went from being "self-aware" of "their own technology views," (N3) to understanding that "technology is not insular, but all connected." (A4) Before, some of

them didn't realise the reach of impacts that smart technology use and production could have in other individuals' lives (A2): "It was almost like it opened a box [they] didn't know was there," with issues they didn't know "needed solving." (A1) In some ways, taking part in co-design studies can be a first point of contact with a considerable volume of information, which can get people interested in pursuing other forms of involvement to make technology more responsible and just.

Awareness was a necessary step in informing participants' **critical thinking**. Participants thought it was interesting that "deeper social and philosophical questions" about smart technology were being approached in the co-design study (A4)—as they expected tech developers not to have the same practice. For N2, the legacy of the workshops has been a more reflective positionality towards what is behind the devices and services they currently use: "I'd like to see the research that ended up with this [technology] because it doesn't necessarily treat me well." Even from a professional perspective, P6 evaluates that they were more naïve before the co-design study, but they now have developed a more critical perspective on the harmful impacts of SHTs: "We definitely need to put some control over it." The learning thread evolved from the empathy of having an open mind to being aware of possible threats and reflecting on them in order to develop critical thinking.

A6 claims to have left the co-design process "with a few ideas and thoughts about how to make improvements in [their] lifestyle." While N3 believes that their "technology anxiety" was reduced—i.e., they feel less anguished and frustrated about their relationship with technology. N6 claims that people "need help to understand what we can do in this crisis that we're all in," and taking part in the co-design study helped them to go forward with their understandings: "I feel much more confident and competent about going forward with new technology." (N6) Empowered by their learning, participants acquire a level of autonomy over technology, being able to discuss it and advise, recommend, and decide whether they want to adopt something.

Being aware of issues and producing a critical view of things are essential aspects of what has been called **empowerment**. The term indicates an opposition to a powerless feeling over a situation. Instead of a passive and tamed belief that one couldn't act on, empowerment indicates someone's will to contribute and multiply knowledge. I argue here that the transformative potential of co-design can support empowerment through learning.

Participants' learning is an intention of co-design processes and, quite possibly, what differs this methodology from previous modes of inclusion like user-centred design. Under such conditions, co-design meetings are also an educational space for all partners involved. Non-professionals taking part, when transformed by new information, are capable of articulating demands from decision-makers. For professionals, taking part in a less hierarchical process can split open a techno-positivist research and development tradition to be affected by transformative subjectivities.

Beyond their empowerment, participants such as N6 revealed excitement about sharing their new knowledge "with people who haven't been lucky enough to be on the study." N3 also highlighted their interest in getting more involved in future participatory research on how AI affects society. Participants seem empowered by the methods employed, with A1 applying the learnt methodological resources in their work environment. The learning curve co-exists with an empowerment curve and is extrapolated by critical **knowledge dissemination**. Resonating theories of critical pedagogy (Freire, 1996), participants' critical consciousness can enable them to not only demand change but act themselves to transform their sociotechnical systems.

From the analysis of the data collected in the evaluative interviews, it is possible to summarise participants' learning journey in four main moments: becoming aware of technology impacts and costs, developing critical thinking over the supposed benefits delivered by SHTs, empowering their personal strategies for technology adoption, and finally, encouraging them to disseminate their insights.

6.3.3. Research Insights From Within the Process

Based on participants' evaluation and the experience of organising this research, it's possible to say that co-design can go beyond deliberating the pros and cons of technology and enable people to have a balanced relationship with it. This can potentially lead to further structural changes in the dominant and unequal sociotechnical system.

The current study has also generated insights specific to making co-design methods more responsible and just. When associated with an equal distribution of decision-making power in a participation infrastructure that prioritises mutual learning, such insights can leverage the inclusion of the external public in technology design to a transformative level.

Three main research learning emerged from participants' evaluation of the co-design process: first, they recognised the privileged hierarchical position enjoyed by professionals in SHTs co-design studies and the inherent responsibilities of such roles; second, they understood that co-design could support users' autonomy, not only through responsible and just devices but also with more deliberative technology development for those who want to participate; and finally, participants' discussions and co-designed artefacts seemed to enact well-known ideas on how to cope with current global challenges, depicting the potential of existent practices.

When evaluating the co-design process focused on troubles and not searching for techno-fixes, A7 hoped that such practices could "enable people who are involved in the development of smart technologies to actually hear what the public say and take on board some of their concerns and some of their ideas," instead of designing something that is

"cool." From a professional point of view, P5 believed that the co-design study helped them understand "what kind of preparation and stimulus the [external public] need to be able to work together [with industry] to generate ideas."

Professionals working behind technology inclusion or responsibility frameworks are the ones detaining the knowledge of the means of technological production. That alone places such individuals in a more privileged position when compared to adopters' capacity to act on their sociotechnical systems. Even if technology design claims to be open for people to participate (through participatory design, user-centred design, or co-design), organisers hold the power to determine how and when participants can contribute. Therefore, a more reflective industry is necessary and seems to be nothing more than their responsibility. Recognising the power dynamics between stakeholders or participants in co-design can be a starting point.

For N1, engaging the "public opinion on how things could be should lead the future for big tech companies"—as expanding inclusion can provide a "better understanding of how the wider population thinks about technology," (N2) and, therefore, technology will be "designed for that broad spectrum of people rather than an exclusive group." (A1) Active participation in technology development should be available by default. Being "available" means that such a process is transparent and intelligible to people without professional training. Instead of a smart technology design that enhances individualism, multiple stakeholders' roles can be recognised in the constitution of sociotechnical systems.

Apparently, being part of co-design and sharing relevant information broke through "people's comfort zones," (N6) with modern life privileges that can keep society in a crisis like climate change. Co-design can inform the public and decision-makers of possible ways to act through more tactile representations of technology responsibility and justice (N7). Furthermore, from a long-term perspective, users and consumers who have the knowledge to decide when and how to participate in technology development are also equipped to pursue levels of technical autonomy.

Finally, N6 recognised that participants' ideas originate in "traditional ideas that have been floating around for many hundreds of years from all over the world." The speculative interventions co-designed by participants to stay with the troubles surrounding SHTs (Chapter 5) are based on provocations from their *imaginaire*, which is empirically constituted by their everyday life experience. As indicated in one of the ten design justice principles (Costanza-Chock, 2020), respecting the value of existing creation and design practices is fundamental for more responsible and just forms of participation. The challenge here is to avoid exploiting and decontextualising existing working alternatives but, instead, facing the troubled collaborations of designing "with" improbable partners.

In summary, the responsiveness and reflective nature of co-design allowed for a research learning journey. Three main research insights have been acknowledged: the responsibility inherent to the privileged position of decision-makers enjoyed by professionals and researchers, the need for technology development to be deliberative, and the usually overlooked potential of existing practices in dealing with global challenges.

6.3.4. Section Summary

This section has demonstrated co-design's capacity to support a mutual learning process. The process can empower co-designers by nourishing their critical consciousness in making informed decisions. In the case of the current research, co-design helped participants to pursue their technological autonomy. In doing so, they can better raise claims and challenge the dominant *imaginaires* behind the development and use of SHTs.

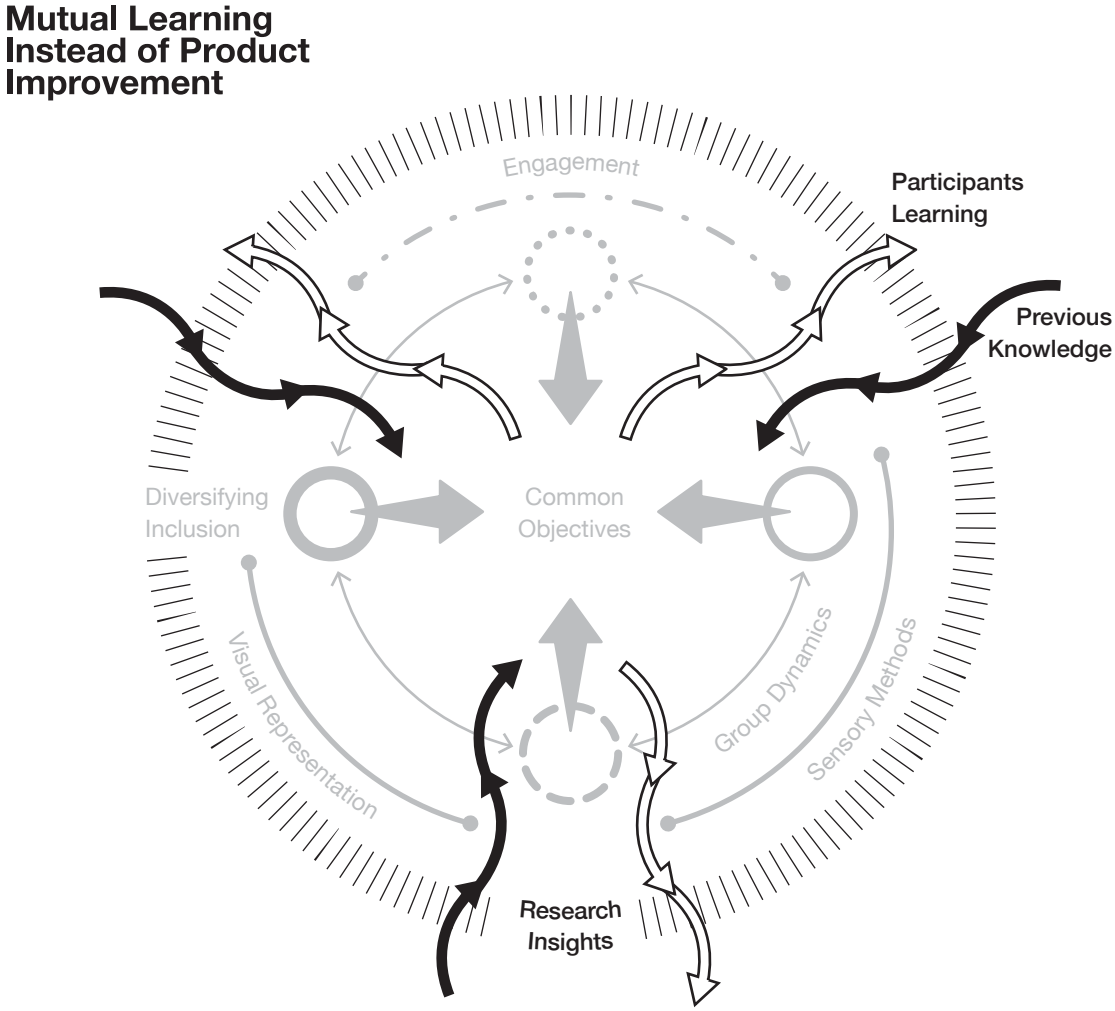


Figure 6.3 - Diagram summarising co-design as a mutual learning process, where participants bring their existing knowledge and learn new information, which can then empower people in challenging dominant SHT imaginaires. The research insights referring to co-design's reflective nature encompass all previous themes represented in the diagram.

The diagram in Figure 6.3 summarises the three streams of mutual learning enacted in this research through co-design. People taking part in co-design bring in their experiences and knowledge. Participants' **previous knowledge** [Figure 6.3] reveals needs and concerns from their *imaginaires*, influencing the co-design of speculative interventions—highlighting the relevance of existing practices known to participants.

The structured information participants could access when participating in the co-design study has been combined with their peers' knowledge, initiating an empowerment journey that starts with awareness. **Participants' learning** [Figure 6.3] passes through the development of critical thinking over smart technologies and then extrapolates the research space towards their everyday lives. Participants feel confident in disseminating the learnt knowledge and have the autonomy to further deliberate about how smart technology is currently being designed. Recognising the privileges of organising a participatory study has been part of the **research insights** [Figure 6.3]. As a non-rigid method, co-design must be reflective, with a practice that can adapt to people taking part.

Based on the evaluation of the co-design process performed in this research, I have been claiming that a balanced power dynamic, established through an accessible participation infrastructure, with the objective to encourage participants' mutual learning, can bring more responsibility and social justice to co-design practices. The following section will further expand on the implications of such transformative characteristics of co-design.

6.4. How to Achieve Structural Change

> "I use it. But I don't want it to use me" (N7)

Relying on the experiences of the co-design study, this chapter evaluated the method's potential to enable more responsible and just participation in the design and development of smart home technology. I have claimed that co-design is not inherently a responsible or just practice but conditioned to a fairer distribution of decision-making power, methods, and spaces capable of augmenting people's participation through a liberating mutual learning process. This final section will organise the three main implications of co-design as enablers of broader societal change.

As a participatory method, I have evaluated how social dynamics are expected to be reproduced through co-design participants' interactions. To avoid inequalities and injustices, it is essential for the diverse group of people taking part to elect common goals democratically. The infrastructure provided to participants is also fundamental for the process to be transparent and intelligible. Instead of product improvement, the focus of co-design should be mutual learning, encouraging participants' empowerment through critical consciousness.

The final aspect to be evaluated from the trouble-focused co-design study regards its implications. Three hierarchically dependent levels of impact were identified in correspondence to the three main themes of this chapter: inclusion that informs decision-makers, infrastructure to revamp industry-user relationships, and learning journey to challenge dominant *imaginaires* behind the development and use of SHTs. The three implications should not compete or be prioritised but co-exist and foster each other's maintenance. Decision-makers informed by various perspectives can foster transparent and responsible relationships with those affected by smart technology, thereby co-designing a fair distribution of benefits and burdens that contest broader social structures.

6.4.1. Inclusion to Better Inform Decision Makers

The first implication of co-design is its capacity to better inform decision-makers by including historically excluded social groups in the design and development of technology. When evaluating the implications of the co-design study, participants mentioned that after producing so many diverse views on smart technologies, the study could help innovators, governments, and people building smart homes (A6). The study then informs the industry and policymakers as they are "who can take action," (N7). The governance power is not expected to be with public society but with governments and regulatory bodies (N7). It's possible to see that some people taking part in the co-design study believed that only powerful stakeholders, like industry or government, can effectively change the development and use of smart home technologies.

A government informed by co-design is able to regulate industry according to the needs of the people affected by technology development (N1). However, powerful actors are expected to act in favour of their interests, aligned with dominant sociotechnical systems that maintain power through poor distribution of technological benefits and burdens.

As previously argued by Sanders and Stappers (2008), practices like user-centred design treat participants as research subjects (Subsection 2.2.2). With co-design, there's an opportunity to discuss the constitution and contest the distribution of power among sociotechnical systems. Thus, the process accommodates a more diverse group of participants acting as partners in an open conversation. Therefore, reflecting on participants' feedback and my experience as researcher-facilitator, it's possible to state that co-design can better inform industry or policymakers because more diverse *imaginaires* are being represented by participants/partners—considered experts in their everyday lives, raising claims and leading discussions instead of merely reacting to a product.

6.4.2. Infrastructure to Revamp Stakeholders' Relationship

The second implication of co-design is to revamp the relationship between industry (people creating technology) and users (people affected by the technology being made) through a transparent and intelligible participation infrastructure. A popular claim in SHT studies has been of an apparent "gap" between the computer sciences/technology industry and social sciences/users (Aldrich, 2003; Gram-Hanssen and Darby, 2018; Leitner, 2015). Such distance was considered one of the main reasons for smart technology's unexpected harm and even for a lack of adoption.

User-centred design has been widely employed as a successful strategy for understanding users' preferences and needs and, hence, launching products that are more aligned with the consumer market. However, techniques like usability tests do not aim to fill the "gap" between industry and users. The aim is to improve products, not to align the knowledge produced by computer science and social sciences. In certain ways, user-centred design splits the two groups even further apart.

As seen in Section 6.2, the methods employed in this co-design study were essential for the enjoyment and engagement demonstrated by the people participating. When associated with participants who wish to contribute and continue participating in long-term SHT deliberation, this can be a potential bridge between those creating the technology and those being affected by it.

More people can participate with a more accessible understanding of the topics being discussed. Grounding abstractions, concepts, values, or ideas in prototypes and visual representations can bring the discussions closer to real everyday life, allowing people to reflect on and empathise with what is being discussed and develop a critical perspective. Such changes in the industry-users' relationship can temporarily position social groups with diverse access to decision-making power in a more horizontal and democratic participation infrastructure. Still, industry or researchers hold the power to close off collaborations. Therefore, a revamped relationship between the diverse group of people participating in technology development is not enough for co-design to challenge current irresponsibility and injustice around SHTs.

6.4.3. Learning to Challenge Dominant Imaginaires

Co-design's third and last implication is that it can empower participants to challenge dominant *imaginaires* behind SHTs by focusing on mutual learning. Again, co-design contrasts with the industry's user-centred design, as the latter is not expected to provide participants with any form of learning—in a revealing nomenclature, "users" are the subject being apprehended by researchers. In co-design, after diversifying the open information channel with decision-makers and infrastructure by new methodologies, people feel safe and empowered to demand change.

As experts in their everyday lives, participants bring previous knowledge to co-design. Besides learning about each other's perspectives and opinions, participants can also be presented with new information. In the case of the co-design study, participants were first encouraged to express their *imaginaires* about smart homes, and only after that were additional details about SHTs' impacts provided. The correlations and reflections participants elaborate after that constitute the learnt knowledge they take with them. Such reflections can extrapolate co-design when participants develop a critical consciousness—something distant from what is expected from people participating in user-centred design. The mutual learning is then completed with insights relevant to future participatory research, emerging from the analysis and evaluation of the co-design study.

Considering the evaluative analysis of the co-design study, I claim that the method's capacity to transform broader societal structures is associated with the co-existence of its three levels of implication: diverse co-design that constantly **informs** decision-makers through **revamped** and open relationships between stakeholders can facilitate individuals' learning to critically **challenge** discourses, opinions, and *imaginaires* behind dominant sociotechnical systems. If co-design doesn't enact the three implication levels, there will only be partial transformations. In the context of this research, a co-design without one of its structuring characteristics (balanced power dynamics, accessible participation infrastructure, and mutual learning aim), is not capable of guaranteeing a more responsible and just development and use of smart home technologies. Without broader, structural, and affirmative social transformation encompassing the process, co-design risk not being that different from previous hierarchical and solutionist inclusion strategies in technology design.

7. Conclusions

This research has demonstrated how the designerly ways of knowing, thinking, and acting in co-design can be enacted to stay with the troubles surrounding the development and use of smart home technologies. In such a process, critical consciousness over the industry's accountability was fostered among Professionals, Early-Adopters, and Late/Non-Adopters, enabling them to challenge the tech solutionism, deepening social inequalities, spreading pervasive surveillance, and worsening the environmental impact of SHTs.

The research design has been framed as a four-phased co-design process. The first phase of this study has characterised the dominant *imaginaires* behind SHTs development and use. In order to achieve this, it was essential to build a common ground paving the way for subsequent collaborations between Professionals, Early-Adopters, and Late/Non-Adopters. At the same time, their expectations and pre-conceptions over smart home technologies were then awakened to guide the following design exercises.

The analysis of such exploration of *imaginaires* was reported in Chapter 4, which presented three main findings: (a) the three samples have defined smart homes with a similar apparent positive tone, with the expectation that, through connected devices, the house can do tasks in householders' behalf—generally overlooking the social and environmental implications of SHTs. (b) The dominant aesthetic expression of their SHT *imaginaire* also responds to a broader modern style, with specificities associated with each sample priorities (e.g., for Late/Non-Adopters, an American Craftsman bungalow better represented their wish for a resilient smart home that maintained a heritage, traditional aesthetic). (c) The dominant SHT *imaginaires* are being informed by professional experience and pop media idealisations about the future of living. The comparison of samples' *imaginaires* revealed common techno-positivist discourse standardising the way they imagine SHTs, disregarding the assumption that a gap between industry and users' technological visions is responsible for SHTs' irresponsibilities. Instead, the harmful implications are connected with the lack of representation of diverse technology

imaginaires, reinforcing unfair access to benefits and risks. Additionally, I claimed that, for a more responsible and just SHTs, it is necessary to focus on each sample's singularities and the oppositions or troubles surrounding the technology development and use.

Instead of positioning the co-design process on a problem-solution trajectory, this study's second and third phases encouraged them to reflect and speculate on the tensions, contestations, and oppositions emerging from comparing their SHTs *imaginaires*. As they practised staying with SHTs' troubles through discourse design methods (like speculative design), participants better framed their understandings of smart technologies' problematic development, unsustainable use, and undesirable socio-environmental impacts.

The analysis of this "trouble-focused" co-design was reported in Chapter 5. The chapter presented three main findings: (a) participants prioritised transforming current individualistic, unsafe, and unsustainable interactions with smart home technology, promoting healing and empowerment instead of a solutionist commercial growth. (b) Participants elaborated on a complex network of troubles encompassing controversial aspects of the direct use of SHTs, their opaque production and overconsumption, and the broader, problematic relationship with technology in general. (c) Participants have designed speculative interventions that provoked reflections across different foci to stay with the troubles, clarifying that more responsible and just SHTs require collective and systematic organisation. Besides being transformative for participants' SHT *imaginaires*, the foci of speculative interventions and the types of troubles they've speculated on have demonstrated critical consciousness over how the industry's solutionism reinforces an irresponsible and unfair sociotechnical system. This new perspective affected the initial SHT *imaginaires* characterise in Chapter 4.

Taking a step back from the co-design practice, the fourth phase of this study evaluated the process analysed in Chapters 4 and 5. As mentioned in Section 2.3, this meta-reflective moment is not commonly found in previous SHT co-design studies. However, based on participants' feedback and my experience running the research design, this phase was indispensable to underpin the aspects capable of rendering co-design as a responsible and just form of inclusion for technology design.

I have discussed such transformative potential in Chapter 6, reporting on three main findings: (a) for a co-design to be transformative, it should be possible to balance the power dynamics encompassing the process. This can be achieved by diversifying inclusion, electing common objectives, and establishing an open and democratic conversation between participants. (b) Moreover, an open and accessible participation infrastructure is essential for transformative co-design. This can be framed by visual and sensory methodologies serving as cognitive support, capable of rendering tactile abstract concepts while not neglecting participants' engagement. (c) Finally, the purpose of a transformative co-design should be mutual learning, not product improvement. By fostering participants' empowerment journey from awareness to critical consciousness,

co-design recognises their existing everyday life knowledge as relevant expertise while allowing researchers to become responsive to their insights from within the process. In summary, co-design can promote a more responsible and just smart home technology if a diverse and fair inclusion is informing decision-makers, relying on accessible, non-exploitative methods revamping stakeholders' relationships, and, consequently, aiming at users empowerment to raise claims against techno irresponsibilities, and challenge dominant *imaginaires* to create a fairer distribution of SHTs benefits.

The chapters summarised above reported on a learning process with contributions from all the individuals involved. Instead of improving a marketable product, this Research-Through-[Co]Design focused on generating evidence-based knowledge to critically evaluate the current design of smart home technologies. Besides transforming participants' relationship with technology, the co-design process produced insights to tackle the three research questions.

7.1. Answers at Last

The initial review of the literature on smart home technologies in Chapter 2 influenced the framing of three main questions for this research. These questions, in turn, informed the research design described in Chapter 3. After analysing the results introduced in Chapters 4-6, I can delineate answers.

The first question this research intended to answer was relative to the assumption that stakeholders' different expectations and needs over smart homes could be associated with the technology's undesirable impacts documented. I.e., if known by the industry, user needs and wishes could be enough to cease SHT-related problems. The concept of *imaginaire* (Bachelard, 1971; Durand, 2016; Wunenburger, 2020) helped frame this question, positioning that the analysis of what an individual carries as representations and metaphors of SHTs can depict their process of attributing meanings to the same technology. Thus, I have inquired: **(RQ1) What are the dominant *imaginaires* shaping the development and use of smart home technologies?** Based on the data collected in Phase 1 with professionals working on SHTs, adopters and non-adopters of the technology, and its subsequent analysis reported in Chapter 4, I have identified an apparent flatness (or standardisation) to how the three sample groups imagine SHTs. This is characterised by modernist representations of smart homes that have endured since the 19th century. Such dominant *imaginaire* reinforces an understanding of the smart home as "the house of the future" symbolised by mass media products (e.g., The Jetsons, James Bond, etc.), carrying an implicit significance of positivism discourses pro-industrialisation. Distancing any dissident or critical interaction with smart technologies seems to keep a low contrast between distinct social groups' *imaginaires*. Individuals

are then rendered passive consumers, and fewer questions are raised against dominant discourses, maintaining the smart technology market in a steady growth while consumers imagine that SHTs are just the next "natural" step.

Following the concept of *imaginaire*, the second question this research intended to answer had a constructivist tone for assuming that if SHTs stakeholders' expectations and needs are informed by their empirically built *imaginaire*, those can be collectively re-built to demand a more responsible and just future with SHTs. In a methodological articulation of previous studies in tech responsibility through inclusion with the need to challenge existing unfair power structures in dominant *imaginaires*, I have positioned co-design (Sanders and Stappers, 2008) as a practice of staying with the troubles (Haraway, 2016) of SHTs. Thus, I have asked: **(RQ2) How can co-design methods affect the *imaginaires* behind smart home technologies?** Answers emerged from running such a co-design study and analysing the data, which was mostly collected in Phases 2-3 (reported in Chapter 5). I have concluded that a trouble-focused co-design can systemically affect *imaginaires*, asking professionals, adopters and non-adopters of SHT different reflection focuses ranging from product usability to production and consumption regulation and even major interventions in sociotechnical systems. Participants improved their understanding of social, political, and environmental problems surrounding SHTs through speculative discussions. The co-design was essential for participants to consider their priorities as co-designers of their sociotechnical system. As troubles associated with technology research and innovation are expected to persist, approaches like co-design can critically encourage alternative interactions with smart technology, diversifying SHT *imaginaires* and challenging the current distribution of benefits and risks.

The increasing number of studies framing their inclusion strategies as co-creation or co-design seems to popularise the term as a generic buzzword, not as a replicable methodology. Therefore, the third and last question this research intends to answer is associated with the aim to contribute to the consolidation of co-design as a transformative methodology (Kensing and Greenbaum, 2013; Sanders and Stappers, 2008; Simonsen and Robertson, 2012; Steen, 2013; van den Hoven et al., 2015). In trying to understand the differences between participatory and user-centred design, I have reflected on: **(RQ3) What are the implications of co-design for creating more responsible and just smart home technologies?** Based on the constant feedback from participants during Phases 1-3 and my own experience in running the workshops, focus groups, and interviews, I have claimed that a trouble-focused co-design has three main implications: first, through diversifying sampling, the process has balanced power dynamics which can better inform decision-makers about the needs of social groups historically excluded from technology development. With the inclusion of diverse stakeholders guaranteed, the trouble-focused co-design has revamped the often-exploitative relationship established between industry and users, relying on an accessible and engaging participation infrastructure. In a third instance, with a balanced inclusion and a revamped form of participation, the

co-design has stimulated participants' critical consciousness through mutual learning, empowering them to challenge the unfair dominant sociotechnical systems, demanding more responsible and just technologies.

7.2. Contributions and Implications

On the way to answering the questions mentioned above, this research intends to support future co-design practices that call for a change in how smart home technologies are currently conceptualised and developed. Advocating for a shift away from industry-driven solutionism towards frameworks interested in co-designers' mutual learning about their lived experiences. In doing so, this research presents three main contribution streams: conceptual, methodological, and empirical. Implications of each contribution are envisioned for design practitioners, researchers, and policymakers.

The first contribution came as a novel **conceptual** framing of smart home technologies through the troubles surrounding them and not the solutions they can provide. I previously demonstrated the influence of industry's techno-positivism in the way smart technology is designed today (Chapter 2)—with the trust that any problem, tamed or wicked (Churchman, 1967), can be solved with technical advances. It is also known that previous technology innovation processes lack infrastructure at the design's 'fuzzy front-end', resulting in a poor understanding of the troubles around the products being developed (Subsection 2.3.1). As evidenced in Section 5.2, SHT troubles have a systemic nature, with pitfalls beyond the production and consumption chain, reaching the very relationship between individuals and their technical objects. Previous solutionist framings of technology design fail to understand this systemic reach of SHT troubles and, thus, produce limited solutions, risking the creation of new problems. I argue that, without directly confronting the systemic inequities and environmental harms inherent to SHT development, technology design practices risk perpetuating the very irresponsibilities they aim to address. I.e., a poor and rushed framing of SHTs troubles in the design's front end may jeopardise any potential benefits that smart technology could yield. As a democratic and participatory practice, if co-design deliberately fails to incorporate social justice discussions, the process won't enact its transformative potential in empowering the public to challenge unfair sociotechnical systems.

In terms of implications, industry has the opportunity to incorporate a better understanding of the troubles bothering consumers. This can be achieved by allocating more time and resources to engage more thoroughly with SHT's 'messiness'. For instance, what is often restricted to the initial stages of design for technological innovation (Kim and Wilemon, 2002), can disrupt further stages of smart technology development. The focus on SHT troubles can be strategically leveraged to create opportunities for deeper reflection, fostering a more responsible approach to addressing people's concerns. Practitioners won't need to change their design training, only shift the intentions of the

design process and better position themselves among the diverse forms of inclusion in technology design, intentionally avoiding the unjustified use of exploitative methods. As elaborated throughout the thesis, co-design methods present an opportunity to discuss the constitution and accumulation of decision-making power in technology design and research. Thus, researchers can test experimental hierarchies, expanding the existing literature and positioning co-design as a transformative way to practice social justice in technology development—instead of being a buzzword to call attention in grant applications. With a clearer understanding of the troubles surrounding SHT development and use, policymakers can potentially start looking at the unregulated and opaque forms in which external public insights are incorporated by big techs in product development, fostering more reflective technology governance.

The second contribution of this research is **methodological**, focusing on SHT troubles through a non-solutionist, discursive co-design process. I have described a novel "trouble-focused" co-design, considering its designerly capacities to deal with complex and wicked problems. Distancing co-design from user-centred practices, I proposed a framework that prioritises mutual learning and democratic engagement over product improvement. This approach enabled participants to collectively problematise the broader sociotechnical troubles embedded in SHTs and imagine alternative futures resisting solutionist and market-driven paradigms. Co-design revealed itself as a potent tool for addressing the immediate usability and adoption challenges and fostering critical reflection on the broader systemic implications of smart home technologies.

Such "trouble-focused" co-design can instrumentalise practitioners in transforming their methods towards less solutionist and more responsible practices. Such transformation also implicates establishing a fairer, accessible, and mutual relationship between stakeholders—potentially bridging the knowledge and expectations gap between industry and users. The methodological instruments presented in this co-design study can exemplify how industry can expand design's 'fuzzy front-end' (Kim and Wilemon, 2002). A "trouble-focused" co-design can leverage the competitive advantage of a robust FFE throughout the entire innovation process, strategically disrupting dominant imaginaires of innovation to ensure that technology development remains adaptable and responsive to SHT troubles. The discursive design methods employed are also considered unconventional to academia, yet they exemplify the contribution of speculative and fictional creative practices for more transformative and resilient future participatory research. Such methodologies can enact a reflective governance of innovation by revealing implicit and subjective aspects of technology development in different levels (product, regulatory, systemic), which is useful for policymakers to tackle the often-opaque troubles of technology from within the development process.

The third contribution is from an **empirical** class, with the co-designed speculative interventions encapsulating participants' journey in developing their critical consciousness over SHT systemic troubles. As noted by Sanders and Stappers, creative

generative sessions where participants craft physical artefacts allow them to express tacit and latent knowledge, encouraging deeper reflections often absent in non-interactive social sciences research methodologies—e.g. interviews or observations (2012). The integration between the different phases of a co-design process (Section 3.1) and the use of discursive design methods like speculative design made it possible to bring awareness to the irresponsible ways smart technology has been designed and consumed. It is difficult to ignore the physical manifestation of participants' discussions and criticisms over SHTs, as well as their expectations for more responsible and just smart technologies. Through this evidence, it was clear to me that co-design needs to be contextualised in broader social, economic, and environmental structural changes to differentiate itself from the traditional design hierarchies.

For practitioners in industry, the empirical evidence presented by this research can directly inform the future design of SHTs on themes and aspects often overlooked by previous studies. The publicly available qualitative datasets documented and organised by this research [Appendix E, Section 1] can help widen the representation of SHTs stakeholders' *imaginaires*, potentially making technology itself more diverse. Additionally, the empirical contribution can signalise to practitioners when (and if) the design of future smart technologies is needed or necessary. Implications for researchers include further advancing discussions surrounding the often-simplified profiles of SHT stakeholders. The visual and speculative insight of this research demonstrates how stakeholders are complex and constantly varying, having multiple dimensions associated with them (e.g., professionals are also early adopters of the technology they help create). In the case of policymakers, the provocative evidence on how professionals, adopters, and non-adopters of SHTs have diverse demands and expectations can promote regulatory streams not envisioned before, promoting dynamism to a systemic technology governance—going beyond conventional RRI frameworks.

7.3. Future Research

As demonstrated in the previous section, the implications of this research for future academic studies range from potentially advancing the collected empirical evidence on how professionals, adopters, and non-adopters imagine SHTs to incorporating discursive design methods as a form of practising social justice in their co-design studies. Nevertheless, there is a need to challenge the industry's technology push and solutionism further to create a more responsible and just development of smart technology. Based on the experience and evaluation of this research, I claim that funding bodies like UKRI and European Commission Horizon must demand from academia and industry a more transformative approach to inclusion in smart technology design, going beyond limited RRI checklists and incorporating social justice practices towards a fairer distribution

of research and innovation benefits. Thus, this thesis will be concluded by highlighting three aspects that future research should incorporate to enact co-design's transformative potential.

7.3.1. Promote and Be Open to Trouble, Chaos, and Disorder

Co-design research and practice must embrace the confusing conglomerate of contrasts existing among participating people and objects. An uninterrupted calamity state of political extremism, post-truth, and environmental emergency frames the saturated distribution of information in contemporary sociotechnical systems. The 19th century-dreamed acceleration of social and economic interactions has been demanding unfeasible deadlines, met by half-finished technology devices, multiplying opaque risks to society. The industry's outdated linear and replicable rational design (mentioned in Subsection 2.2.2) simply cannot cope with contemporary demands. It requires first organising and taming today's wicked problems so a limited group of professionals can apply a *life-human-consumer-user-centred* design thinking workshop to solve things with a 3D-printed plastic prototype.

More than ever before, today's design practice must reconnect with reflective paradigms (Schön, 1986), understanding not only its capacity to give shape to wicked problems but also the potential of diversity in collective design practices. As I mentioned throughout the thesis, the designerly ways of coping with uncertainties are useful here, as well as its speculative nature (Cross, 1982). Diverse design partners can bring contrasting perspectives in their way to stay with troubles, chaos, and disorder. Without trying to organise it or co-design ways out of the apparent chaos, but by co-designing *in*, *with*, and *despite* the troubles. In fact, staying with and co-designing for trouble, chaos, and disorder can help trigger the necessary change in current unfair sociotechnical systems.

In this research, I demonstrated the uses of disorder in co-design in two main ways: first, by including a technically diverse sample, and secondly, by co-designing speculative interventions to stay with the troubles in SHT *imaginaires*. The reflections provoked by the trouble-focused co-design have led to moments of orchestrated chaos in which dominant *imaginaires* could be displaced in favour of the diversity of perspectives and narratives presented by participants.

Based on the experience of running this research study, I argue that more can be done to advance trouble, chaos, and disorder through inclusion strategies and speculative methods. First, robust inclusion strategies can promote discussions over the distribution of power to enact a specific sociotechnical agenda, and if there is sampling bias towards one social group, the discussion won't be as democratic. Concepts like intersectionality (Costanza-Chock, 2020; Sharma et al., 2023) seem to be interesting starting points for more just inclusion in technology design. Secondly, in terms of methods, staying with the trouble and orchestrated chaos can be further advanced, bringing disorder to other

steps of technology design. For instance, trouble could manifest by deploying functional prototypes of speculative artefacts (like this research's interventions) for developers and designers to use. It can be difficult to ignore the physical manifestation of the troubles caused by the technology they helped to develop, which can encourage more responsibility in technology design. In addition to the presented concept of trouble (Haraway, 2016), further support from the uses of the disorder (Sennett, 2021) can be a starting point here.

7.3.2. Recognise its Systemic Nature

Co-design has the capacity to cope with different dimensions and levels of a design problem, and for that, it should be considered a systemic approach. As mentioned previously, different research and innovation frameworks have been trying to tackle the irresponsibilities in SHTs' development, deepening social inequalities, spreading pervasive surveillance, and increasing environmental impacts. The many forms of bringing more responsibility to technology design seem to consider the inclusion of the external public as essential. Nevertheless, as the forms of inclusion in technology design follow the characteristics of the period's sociotechnical system, previous frameworks tend to have a unidimensional priority. The Scandinavian participatory design, for instance, is rooted in the action of organised social groups to promote better work conditions (therefore focused on the means of production), while the North American user-centred design is organised to increase profits through improved usability (with a product focus). However, participatory design does not account for the products produced by industry, and user-centred design does not challenge the means of production.

In the contemporary context, inclusion methods focused on a unidimensional priority seem to overlook the systemic nature of wicked problems. As demonstrated in Chapter 5, for instance, the troubles surrounding SHTs seem to respond to an overlapping system of tensions, oppositions, and contestations, ranging from product interactions and usability to technology production and consumption regulation, characterising individuals' broader relationship with technologies. Co-design was capable of staying with such diversity of troubles congregating and schematising multiple foci in SHT's sociotechnical system.

Co-design's systemic nature can provide a comprehensive, holistic perspective on the troubles surrounding the practice. This holistic perspective is not accidental but rather a result of democratic dynamics between people taking part in co-design research. Because of a broader awareness, participants can experience critical consciousness through mutual learning. Such empowerment can lead to further disruption in a sociotechnical system—thus, practitioners should proceed with care if personal revolutions are not an aim of the study.

This research has approached co-design as a systemic practice by presenting the diverse group of participants with prompts to expand their demographic limitations, like the methods described in Phase 2 of data collection (Section 3.3). Another manifestation of this characteristic could be seen in correlations between speculative interventions (Chapter 5). Each intervention presented an independent focus; however, as outcomes of the same co-design process, they could be timely distributed as granular actions to promote a transition towards more responsible and just SHTs. Furthermore, participants reported the intention to change their everyday lives after mutually developing their critical consciousness over SHTs—representing a seed for broader sociotechnical change. From this perspective, I claim that co-design can be better acknowledged as a systemic approach by positioning it as a practice of transition. Useful starting points can be found in sociotechnical transitions (Geels, 2002), transition design (Irwin et al., 2015; Loorbach, 2022), and sustainability transitions (Ceschin and Gaziulusoy, 2016).

7.3.3. Participate in Broader Social Transformation

Co-design should be purposefully deployed to promote responsible and just structural changes in sociotechnical systems. Methods such as participatory design and user-centred design have made an unquestionable contribution to encouraging a more inclusive industry and academia. As I have been arguing in this section, each form of inclusion in technology design should respond to the context and objectives of the development process. Additionally, the chosen methods also need to acknowledge the socio-political dynamics encompassing the process. As discussed in Section 6.1, societal aspects are expected to make their way into a participatory technology design, mirroring external unequal power hierarchies. It is not possible to prevent participants from enacting their privileges and prejudices, but it is possible to trouble such power dynamics, diversify inclusion, and facilitate a learning process targeting critical consciousness. Co-design has the necessary characteristics to allow for such transformative change in participants, and it also needs to deliberatively extrapolate this change to society.

Without promoting social transformation, there are not many differences between co-design and hierarchical design practices like user-centred design. Today's context requires collective action that promotes real change. This doesn't necessarily mean a complete rupture with industry practices like user-centred design, but, instead, a better framing of inclusion processes and when to apply each one. For instance, if one wants to promote social transformation, it should be known that user-centred design won't do it. That is a call for a more mature understanding of co-design as a social justice practice, differentiating it from other forms of inclusion in technology design.

From a normative standpoint, the methodological procedures of this research exemplified how co-design could enact such social transformative capacity. From sampling diversity to visual and sensory methods, this co-design process equipped participants with a critical consciousness regarding the urgency of changes in the way SHTs are designed today

(Chapter 6). The meetings and workshops of this research have opened possibilities for the co-design frameworks described in the literature to be expanded towards principles of Design Justice (Costanza-Chock, 2020), Radical Participatory Design (Udoewa, 2022), and Grassroots Engineering (Cruz, 2021).

I want to conclude by emphasising design's modern origins. It enacts a discourse of rationalisation and ordering of a supposed existing chaos in previous crafting practices. Thus, design is not a neutral methodology. If industry, academia, or policymakers intend to apply, for instance, collective design practices as a fair social change tool, this must be taken into account. A co-design without an affirmative and clear social justice agenda is *just* design.

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9. Appendices

Appendix A. Previous SHT Co-Design Studies

The following Table 9.1 presents the 27 SHT co-design studies from 2004 to 2024, that were analysed in Chapter 2, Literature Review. The table follows a decrescent order starting with the co-design studies including more diverse *imaginaires* and being less solutionist, to the ones lacking diversity and presenting more technofixes.

Table 9.1 - Previous SHT co-design studies analysed in the literature review.

Author(s)	What did they do?	Who was included?	How were they included?	Did they include diverse imaginaries?	Was it solutionist?
Raju et al., 2021	*Co-design of a smart messaging technology going beyond interactions imagined by "conventional" users.*	*Researchers (UK & India), residents of Dharavi, a slum in Mumbai (India), along with local artists and craftsman.*	*Workshops, diary studies, and interviews with residents; conceptual sketching with artists; and low-fidelity prototyping with craftsman.*	*Yes. The process relies on Dharavi residents' needs and expectations, along with their understanding of smart communication technologies. It shows a collaboration with a Global South territory and vulnerable users.*	*No. It doesn't aim to market the product, but rather to support the Dharavi community with a communication technology matching their everyday life. It adapts the methods to make use of local opportunities to engage the community in multiple levels.*
Chidziwisano and Jalakasi, 2023	*Study of design opportunities for smart security system to be safer for women without reinforce patriarchal social norms.*	*Women living in patrilineal communities in Malawi.*	*Interviews during an ethnographic observation at participant's houses; focus group paired up with a design session discussion.*	*Yes. It highlights Malawi women's perspective over security and privacy, which can them be used to developed equitable SHT. It makes visible women's perspectives about designing smart home security systems in patriarchal societies.*	*No. It doesn't intend to solve sexism or patriarchy. Results are presented as "design opportunities" to equitable smart security systems. It demonstrates how unintended impacts can be foreseen before the technology causes harms.*
Kozubaev et al., 2019	*Co-design smart technology features to assess their long-term implications and potentials in public housing.*	*Residents and facility management staff from Atlanta Housing—a subsidized public housing programme in the US.*	*Participatory design workshops with speculative and visual prompting.*	*Yes. It included a wide range of people affected by SHT in the context of public housing. The Atlanta Housing agency approached the researchers with the proposal for the workshops, giving the process a "bottom-up" nature (instead of researchers bringing things to be discussed with recruited people).*	*No. They have used speculative design and participants creative representations to stir up possibilities and risks for the use of SHT in public housing. The results are tailored to benefit Atlanta Housing.*

Author(s)	What did they do?	Who was included?	How were they included?	Did they include diverse imaginaries?	Was it solutionist?
Shakeri and Neustaedter, 2014	*Co-design exploration of SHT for remote co-presence between households.*	*Young adults from Canada, that could potentially become users of co-presence smart technologies.*	*Co-design with interviews, workshops, analysis by synthesis, and usability test.*	*Maybe. The study includes young/emerging adults but does not highlight any other demographic characteristic that would position such group as vulnerable or historically excluded from the design of SHT.*	*Maybe. Results include artefacts that can be prototyped and tested in the field, as well as serve as a discussion and reflection prompts following their speculative nature. Yet, there's a lack of theoretical perspectives, and political or social impacts surrounding the designed artefacts.*
Yao et al., 2019	*Co-design of ways in which users want SHT to protect their privacy.*	*Adults in the US.*	*Co-design workshops with round-table discussions, and scenario-based activities.*	*No. They have not defined the user group recruited and why they were chosen. Beyond that, essential concepts, like "smart home", were pre-defined by the research, lacking participants involvement.*	*Maybe. It's a good example on how visual methods can assist reasoning and research in generating guidelines for the development of future privacy mechanisms.*
Renström, 2019	*Exploring future roles that residents would assume when interacting with SHT.*	*Residents of a living lab for students and staff of a university in Sweden.*	*Home activities and workshops to generate residents' future roles.*	*Maybe. The group of participants is restricted, with little focus on contrasting groups. The tone of the conversation is given by researchers, framing concepts to prompt participants.*	*No. They are not developing a product, but rather discussing social roles' residents would assume when in contact with SHT.*
Cagiltay et al., 2020	*Study to better understand the potential future interactions between in-home social robots and family members.*	*US families with at least one child and one of their parents.*	*Individual "participatory" design with each family, with interview, discussions, and the design of interactions.*	*No. Even with the use of visual methods diversifying analysis, the participatory design sessions only involve a family and the facilitator each time, with no further details on the families' profile.*	*Yes. Results can easily be marketed, and participants are relayed as informants of the process. Leadership is not shared, and critical thinking on robotics is not expected from participants.*
Green et al., 2004	*Study exploring users' physical, cognitive, and emotional needs, to guide the development of SHT.*	*Adults from the UK with and without disabilities, couples with and without children, older adults, and people in sharing houses.*	*Workshops with group discussion, design exercises, and scenario building.*	*Yes. There is an explicit wish to include diverse profiles of users, as they can bring up underdiscussed themes to be incorporated in SHT research.*	*Yes. The study doesn't challenge the growth paradigm associated with solutionism, reinforcing the notion that a smart home would be the "natural" next step in home everyday life.*
Vickers et al., 2009	*Study to understand older adults' expectations and needs over smart technologies in their everyday rural life.*	*Older adults living in a rural area in the UK, all members of the same community art group.*	*Participatory focus group, and individual asynchronous art sessions.*	*Yes. There is an explicit wish to include older adults from rural communities as they are often neglected by smart technology development. They've worked in a familiar venue, using their own expression means.*	*No. Even if some insights can emerge from the study, there is no intention in turning the artworks into products or technical solutions. Yet, there is little time with participants, which limits mutual learning and critical thinking.*

Author(s)	What did they do?	Who was included?	How were they included?	Did they include diverse imaginaries?	Was it solutionist?
Hwang et al., 2012	*Study on interfaces of assistive smart technology for adults living with dementia and their informal caregivers.*	*Informal caregivers of adults living with dementia in Canada.*	*Participatory design workshop with video prompting, reflection, and discussion; Usability test of UI paper prototypes.*	*Maybe. There is an explicit intention to recruit a group underrepresented in SHT design as they are indirect users of the technology. Yet, participants are not directly designing the interfaces, but rather giving their opinions and reactions for it.*	*Yes. The fact that the study relies on usability tests of user interfaces (UI) indicates a focus in improving a product and its market acceptance, and not necessarily developing a critical perspective over it.*
Bourazeri and Stumpf, 2018	*Co-designing the UI of an assistive SHT for people living with early-stage dementia and Parkinson's disease.*	*People living with dementia or Parkinson's disease included as equal partners.*	*Co-design using persona methodologies, discussions, and UI usability test.*	*Yes. There is an explicit intention to include people affected by assistive SHT as equal partners in their design process. There were some efforts in recruiting such vulnerable group and retaining them. Yet, persona methodologies can be limiting as they rely on generalisations of users.*	*Yes. The study presents a smart solution for the everyday life of people living with dementia and Parkinson. Also, the persona methods can avoid the complexity of users, the discomfort of negotiations, or challenging the technology.*
Pradhan et al., 2020	*Design of home automations ideas with older adults.*	*Older adults in the United States.*	*Participatory design with interview, cultural probe, and workshop.*	*Maybe. Even with little information on their profile, it was clear that participants considered themselves designers when referring to users outside the study as "others". Yet, their creations were conditioned to combining existing cards.*	*Yes. The study generates ideas of automations to "solve" older adults' everyday life.*
Cockbill et al., 2020	*Study to explore future energy-related service concepts meaningful to households.*	*Includes householders and smart energy experts from the UK.*	*"Human-centred" co-design with prompt cards, experts round table, and storyboarding.*	*Yes. Even though the different groups of participants are separated, researcher serve as the link between samples imaginaires.*	*Yes. The information provided by the study informs the development of smart energy solutions associated with resources consumption and distribution.*
Garg and Cui, 2022	*Design of future domestic IoT devices that can better support home activities by adapting to social contexts.*	*Adults with varying interest and knowledge about smart homes from the United States.*	*Co-design sessions with design fiction, card sorting, and interviews.*	*Maybe. Even though the study claims that co-design can unlock further ways to understand users' needs and expectations through "tacit values" and "latent needs", there is little information on the sample profile.*	*Yes. Besides the fact that results can be marketed, the study implies that any negative outcomes of SHT would be a result of a faulty device—without questioning the accountability of actors behind its development.*
Reisinger et al., 2022	*User-centred design of various smart energy services, applications, and devices, responding to social practices and values.*	*Characteristics of participants from Austria were not described.*	*User-centred methods like questionnaire, cultural probing, interviews, SWOT analysis, prototyping, and focus group.*	*No. The absent information over the sample's profile indicates a lack of interest in how their experience and imaginaire can go beyond the framing of "users". Also, third-part professional design services were hired to finalise prototypes*	*Maybe. Even though there's no direct indication of interest to market results, they could easily influence new energy SHTs. There is a lack of reflexivity, as authors consider the methodological framework a success without presenting evaluation criteria.*

Author(s)	What did they do?	Who was included?	How were they included?	Did they include diverse imaginaries?	Was it solutionist?
Chalhoub et al., 2024	*Design UX heuristics to address challenges specific to consent and permission in SHT.*	*Adults with technical expertise with SHT in the UK.*	*Online participatory design workshops testing heuristics developed through literature review.*	*No. There is limited information about the sample's profile recruited participating.*	*Yes. There is a clear intention to enhance SHT market acceptance through UX design. Even if the study doesn't result in a "smart" technical solution, it generates knowledge on how to design successful ones.*
Decorme et al., 2014	*Co-design a technological solution for getting a concrete understanding of householder's energy use and consumption.*	*A group of French families.*	*Co-design with interviews and workshops, communicating through a blog, filming to document the process, and exhibition of a final functional prototype.*	*Maybe. Participants were directly involved in designing the final smart energy technology, and there was a dedicated communication channel (blog), internal surveys, and constant process documentation to keep co-designers integrated.*	*Maybe. Even if the result is not expected to be marketed, the study aimed to solve the energy consumption struggles through SHT. Instead of aiming at participants' critical thinking, the data collection informed experts to design a web-based application.*
Ghajargar et al., 2017	*Using an empathy workshop to connect people developing the technology with people using the technology.*	*A group of researchers and users of smart home technologies in Italy.*	*Participatory design session called "empathy workshop", using one-on-one conversation techniques.*	*Yes. Using the concept of empathy and how it can support a more comprehensible and transparent communication between users and developers, they invited the two different profile samples to work around together.*	*No. The empathy workshop is not focused in generating new products, but in the relationship between stakeholders.*
Yao et al., 2019	*Design of privacy enhancing applications and features for smart homes.*	*Participants were from the United States.*	*Co-design with focus group and prototyping.*	*No. Even if they include an often-neglected group of indirect users (bystanders), the absent information over people taking part in the co-design shows a lack of interest in diversifying SHT imaginaries.*	*Yes. Privacy concerns were approached with instant ideas of technical solutions during focus groups—instead of first elaborating on the problems and their original sources.*
Cortellessa et al., 2021	*Design and develop already known ICT interfaces so patients and caregivers could have a better remote support from telehealth.*	*A group of patients, caregivers, and health professionals, and another group of experts, all from Europe.*	*Co-design with focus groups, interview, prototyping, and usability test.*	*Yes. It includes more than one group that will be affected by the technology being developed. They deploy functional prototypes, which can deliver more accurate feedback from real life scenarios. However, participants are relayed as users and not co-developers of the technology.*	*Yes. With a technology-driven approach, they want to solve the problem of communication between patients and telehealth professionals using automation and other smart interfaces.*
Ghorayeb et al., 2023	*Design a smart home control interface to enhance usability and utility of SHT supporting aging in place.*	*Older adults from the UK, with varying levels of experience with SHT.*	*Co-design with focus group, interviews, cultural probe, note taking, and low fidelity UI prototype.*	*Maybe. They have a contrasting sample of users and non-users of SHT. However, the study would benefit with the inclusion of designers or developers expressing their aims and limitations as well.*	*Yes. Even if they've used non-traditional activities and methods for data collection, their aim is to use SHT to solve problems associated with aging in place—instead of allowing participants to discuss the different aging strategies associated with housing.*

Author(s)	What did they do?	Who was included?	How were they included?	Did they include diverse imaginaries?	Was it solutionist?
Fitton et al., 2018	*Design of interactions between teenagers and voice interfaces in smart homes.*	*Teenagers from the same school in the UK.*	*Co-design with paper and digital prototyping, and a questionnaire.*	*Maybe. It includes a group that is not usually represented in technology design. Yet, there is no socio-economic diversity.*	*Yes. Beside the potential of results informing product development, the design process itself uses shortcuts without nudging participants towards technology awareness or critical thinking.*
Pejner et al., 2019	*Design, development, and evaluation of a remote smart health care technology to support aging in place.*	*Participants were from Sweden.*	*Participatory design interview, seminars, prototyping, and pilot testing.*	*No. It doesn't mention to which extend participants got involved in the design of the system and crafting solutions—or if they just informed a technical expert team about their needs and preferences.*	*Yes. They've developed a product, a smart solution that would bring liberation for elderly people aging in place.*
De Ruyck et al., 2019	*Understand how SHT can be designed to account for users' life cycle.*	*A group of adults from Belgium.*	*Co-design including workshops with ideation supported by card decks.*	*Maybe. They try to include users but there is no indication of a contrast in the imaginaries present in the workshops.*	*Maybe. The actionable insights and guidelines generated by the workshops can help industry to produce appealing products for consumers.*
Hunter et al., 2021	*Explore how existing SHT can support remote health care for aging in place.*	*A group of older adults, informal caregivers, and health supporters from New Zealand.*	*Mixed methods involving interviews, focus group, and the co-design of a smart home system's set-up using off-the-shelf products.*	*Yes. They bring perspectives from different people involved in the same practices, and that would be affected remote SHT for health care.*	*Maybe. They don't design any products, but they are suggesting the use of existing products—which they don't challenge.*
Schulz and Hornecker, 2022	*Co-creation of smart surfaces for home interiors of co-living housing arrangements.*	*A group of adults from Germany.*	*Co-creation including cultural probe and online workshop.*	*No. The study assumes that participants would need to be guided to express their SHT imaginaire. Also, the absent information on participants profile might reveal a lack of interest in their subjectivities.*	*Yes. After the results presenting the smart surfaces, there are no further discussions or elaborations on the troubles it would be dealing with.*
Ngankam et al., 2023	*Development of a ludic user interface for older adults to better accept and adopt SHT.*	*A group of older adults living in a private residence for elderly in Canada, presenting little SHT knowledge*	*"Human-centred" design with individual sessions of interview, prototyping, and usability test.*	*No. They've included older adults individually, not allowing collaboration between them—which is the core aspect of co-design. Participants were interviewed, not directly designing.*	*Yes. They've developed and tested a smart home user interface dedicated to elderly people with market potential.*

Appendix B. Participants Recruitment Documents

Section 1. Participant Information Sheet

This project has received funding from the European Commission under Horizon2020 MSCA-ITN-2020 Innovative Training Networks program (Grant Agreement No 955422).

University of East Anglia

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Participant Information Sheet
(Co-Design of Smart Home Technologies Study)

What is this study about?

You are invited to take part in a research study about the design of smart technologies for the home. With your participation, this study aims to generate new knowledge about how smart home technologies can help us transition to a more sustainable future. You are receiving this invitation because you have been considered as belonging to an important group when comes to developing more responsible and just technologies. This **Participant Information Sheet** tells you details about the research study. Knowing what is involved will help you decide if you want to participate.

Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary. By giving consent to take part in this study you are telling us that you:

- Understand what you have read.
- Agree to take part in the research study as outlined below.
- Agree to the use of your personal information as described.
- You have received a copy of this Participant Information Sheet to keep.

Who is running the study?

The study is being carried out by the following researcher(s): Mr Vinicius Pereira, Dr Tom Hargreaves, School of Environmental Sciences, Dr Helen Pallett, School of Environmental Sciences.

This study is part of the GECKO Project (https://gecko-project.eu/) and has received funding from the European Commission under the Horizon2020 MSCA-ITN-2020 Innovative Training

GECKO

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Networks programme, Grant Agreement No 955422 (https://cordis.europa.eu/project/id/955422).

What will the study involve for me?

You will take part in a study splitted among 3 phases, over the next 12 months. As a general characteristics, in every phase you are going to be invited to attend an in person workshop. After each phase, and before the next one, you will receive a summary of results of the previous phase. The referred summary may also contain a short questionnaire related to the results.

The first phase will be a in person workshop (location of the workshop will be specified at the moment of the invitation). The workshop will explore your past experiences and assumptions about smart home technologies. In a set of short activities, you will be asked questions about household everyday life, and the objects that are part of it. Within the workshop you will create visual representations of how you perceive smart home technologies.

The design of the subsequent phases will depend on the outcome of the first round of workshops in the first phase. However, it is anticipated that they will have a similar format and length — i.e., the will be workshops, held in person, where you will be asked to use your life experiences to collaborate in producing representations about smart home technologies. The location, date, and time of the subsequent phases of this study will be confirmed after the first phase, and communicated to you using your preferred contact.

The workshop's audio will be recorded. Photographs will be taken.

How much of my time will the study take?

Every workshop should last no longer than 2h30min, including coffee breaks. Minor remote interactions are expected between every workshop, via e-mail, post or phone call.

Do I have to be in the study? Can I withdraw from the study once I have started?

Being in this study is completely **voluntary** and you do not have to take part.

Your decision whether to participate will not affect your current or future relationship with the researchers or anyone else at the University of East Anglia (or GECKO Project) now or in the future.

If you decide to take part in the study, you can withdraw your consent up to the point that your data is fully anonymised. You can do this by contacting the organisers, using one of the communication channels provided.

What are the consequences if I withdraw from the study?

If you take part in study, you are free to stop participating at any stage. If you decide, at a later time, to withdraw from the study, we will delete any data we are holding from you where you can be identified.

Are there any risks or costs associated with being in the study?

Aside from giving up your time, we do not expect that there will be any risks or costs associated with taking part in this study.

Are there any benefits associated with being in the study?

As part of the study, you would be able to collectively reflect on how your experiences and values shape your relationship with the technologies and objects in your home. Your contribution to the current study will help in building a more inclusive and just development of smart home technologies, benefiting people and their environment.

As an incentive for your participation, organizers will offer **donations or money compensations**, for every workshop you participate. Details on values or charities will be shared along with the invitation to take part at the study.

What will happen to information provided by me and data collected during the study?

Your personal information will only be stored for future contact, inviting you to take part in the next phases of the study.

Your personal data and information will only be used as outlined in this Participant Information Sheet, unless you consent otherwise. Data management will follow the Data Protection Act 2018 (DPA 2018) and UK General Data Protection Regulation (UK GDPR), and the University of East Anglia's Research Data Management Policy.

The information you provide will be stored securely and your identity will be kept strictly confidential, except as required by law. Study findings may be published, but you will not be identified in these publications if you decide to participate in this study.

Study data may also be deposited with a repository to allow it to be made available for scholarly and educational purposes. The data will be kept for at least 10 years beyond the last date the data were accessed. The deposited data will not include your name or any identifiable information about you.

What if I would like further information about the study?

When you have read this information, Mr Vinicius Pereira (v.pereira@uea.ac.uk) will be available to discuss it with you further and answer any questions you may have.

Will I be told the results of the study?

The results of this study will be shared with participants shortly after all the workshops have been completed. You have a right to receive feedback about the overall results of this study.

You can tell us that you wish to receive feedback by You can receive a feedback of this activity if you tick the option to receive it in the activities final questionnaire.

This feedback will be in the form of The feedback will be given in an online format, allowing you to also give comments back.

This feedback will be shared with participants 5 working days after the workshop date.

What if I have a complaint or any concerns about the study?

If there is a problem, please let me know. You can contact me via the University of East Anglia at the following address:

Mr Vinicius Pereira
v.pereira@uea.ac.uk

School of Environmental Sciences
University of East Anglia
Norwich - NR4 7TJ - United Kingdom

If you are concerned about the way this study is being conducted or you wish to make a complaint to someone independent from the study, please contact the Head of School of Environmental Sciences, Ian Renfrew (i.renfrew@uea.ac.uk).

How do I know that this study has been approved to take place?

To protect your safety, rights, wellbeing and dignity, all research in the University of East Anglia is reviewed by a Research Ethics Body. **This research was approved by the SCI S-REC (Faculty of Science Research Ethics Subcommittee).**

What is the general data protection information I need to be informed about?

According to data protection legislation, we are required to inform you that the legal basis for processing your data as listed in Article 6(1) of the UK GDPR is because this allows us to process personal data when it is necessary to perform our public tasks as a University.

In addition to the specific information provided above about why your personal data is required and how it will be used, there is also some general information which needs to be provided for you:

- The data controller is the University of East Anglia.
- For further information, you can contact the University's Data Protection Officer at dataprotection@uea.ac.uk
- You can also find out more about your data protection rights at the Information Commissioner's Office (ICO).
- If you are unhappy with how your personal data has been used, please contact the University's Data Protection Officer at dataprotection@uea.ac.uk in the first instance.

OK, I want to take part – what do I do next?

You need to fill in one copy of the consent form and send it back to the organisers using the e-mail or postal addresses provided. When sending it via e-mail, please attach the Participant Consent Form file in the extensions .DOC or PDF. Please keep your invitation e-mail/letter, information sheet and the second copy of the consent form for your own information.

Further information

This information was last updated on 5 December 2022. If there are changes to the information provided, you will be notified by e-mail or telephone call.

This information sheet is for you to keep

GECKO

ETH2223-0241

Section 2. Participant Consent Form (Printed Version)

ETH2223-0241

Participant Consent Form
(First Copy to Researcher)

This project has received funding from the European Commission under Horizon2020 MSCA-ITN-2020 Innovative Training Networks program (Grant Agreement No 955422).

I, _____[Print Name], am willing to participate in this research study.

In giving my consent, I state that:

- I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.
- I have read the Participant Information Sheet, which I may keep, for my records, and have been able to discuss my involvement in the study with the researchers if I wished to do so.
- The researchers have answered any questions that I had about the study and I am happy with the answers.
- I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of East Anglia (or GECKO Project) now or in the future.
- I understand that I may stop participating in an observation at any time if I do not wish to continue. I also understand that it will not be possible to remove my data unless the observation is videoed or I am individually identified in some way.
- I understand that the results of this study may be published but that any publications will not contain my name or any identifiable information about me.
- I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.

I consent to:

Completing a questionnaire	YES ☐	NO ☐
Audio-recording	YES ☐	NO ☐
Photographs	YES ☐	NO ☐

GECKO

University of East Anglia

The data collected in this study may be deposited with an academic repository to allow it to be made available for scholarly and educational purposes, but the data will not contain my name or any identifiable information about me.

I consent to:

Deposit of data in a repository	YES ☐	NO ☐

Would you like to receive feedback about the overall results of this study?

	YES ☐	NO ☐

If you answered YES, please check your preferred form of feedback and provide an address:

☐ Postal: _____

_____

_____

☐ E-mail: _____

_____
Participant's Signature

_____
Participant's Full Name [Print Name]

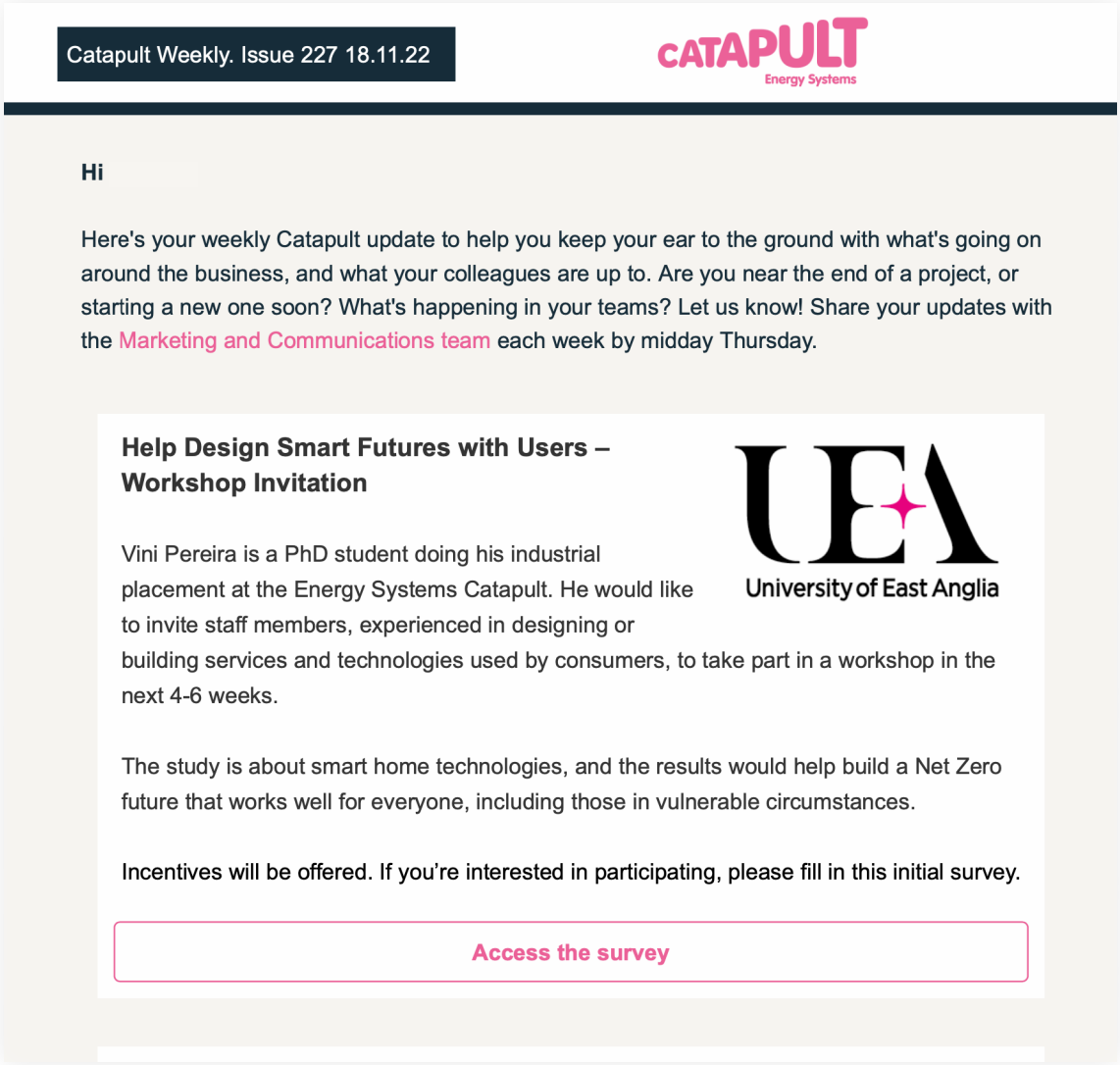
_____
Date

GECKO

UEA
University of East Anglia

Section 3. Professionals' Recruitment

(i). Advertising banner for Energy Systems Catapult's online newsletter



(ii). Initial email contact

Subject: Workshop Invitation — Help Design Smart Futures with Users

Message: Dear [Name of Receiver], Hope you're having a good week so far!

My name is Vini and I'm a PhD student doing my industrial placement at the Energy Systems Catapult with the CI team.

I'm getting in touch because I would like to invite you to take part in a workshop about smart home technologies. The results would help build knowledge around inclusive practices to design a Net Zero future with technology. As an incentive for your participation, I will be offering £10 donations on your behalf to the National Energy Action, a fuel poverty charity.

Do you think you would be available over the next 4-6 weeks?

Please, let me know if you have any questions.

Thank you for your time!

Vini

Section 4. Early-Adopters' Recruitment

(i). Contact Online Consent Form

Do you want to participate in a workshop in Birmingham to help designing smart future?

Hello!

My name is Vini and I'm a PhD researcher at the University of East Anglia (UEA). I've been working with the Energy Systems Catapult team in my industrial training, helping the Living Lab team find ways to better support participants, so we can keep building a Net Zero future that works well for everyone.

I'm getting in touch because I would like to invite you to take part in a workshop in January!

What is the workshop about?
We are looking for Living Labbers interested in taking part in a workshop about smart home technologies. The workshop will explore your past experiences and assumptions about this kind of technology. In a set of short activities, you will be asked questions about household everyday life, and the objects that are part of it. Within the workshop you will create visual representations of how you perceive smart home technologies. The workshop should take less than 3h.

You are receiving this invitation because you have been considered as belonging to an important group when it comes to developing more responsible and just technologies. This workshop is the first part of mine PhD research study, and if you decide to participate, you will have the chance to also take part in the subsequent parts.

Who is running the study?
The responsible researcher for this study is Vinicius Pereira (or Vini), under the supervision of Dr Tom Hargreaves (UEA), Dr Helen Pallett (UEA), and Prof Charlie Wilson (Oxford University).

This study is part of the GECKO project, and has received funding from the European Commission (Grant Agreement Nº955422). As part of the programme Marie Sklodowska-Curie Actions as an Innovative Training Network, the GECKO project is composed of different academic and industrial partners (https://gecko-project.eu/).

Are there any benefits associated with being in the study?
If you take part in the study, you will be offered a £45 voucher compensation for your participation. Transport compensation of up to £30 will be offered to support your trip to the workshop venue. The workshop is to be held at the Energy Systems Catapult office, in Birmingham City Centre.

Do I have to be in the study? Can I withdraw from the study once I have started?
Being in this study is completely voluntary and you do not have to take part. If you decide to take part in the study, you can withdraw your consent up to the point that your data is fully anonymised. You can do this anytime, by contacting the responsible researcher, using one of the communication channels provided.

If you're interested in participating...

For now, you just need to express your interest by filling in the following Contact Consent Form. Later, you will be sent the complete information about the study as well as a participation register form.

By filling in the following contact consent form, you are agreeing to the responsible researcher at University of East Anglia storing your contact details for the purposes of sending you more information about the study.

Please, let me know if you have any questions.

Thank you for your time,
Vini
v.pereira@uea.ac.uk

* Required

Contact Consent Form

In giving my consent, I state that:

- I have read the information provided in the description of the current form.

- I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the Energy Systems Catapult or at the University of East Anglia (or GECKO Project), now or in the future.

- I understand that the personal information about me that is collected will be stored securely and will only be used to contact me with further information about the proposed study. I understand that information about me will only be told to others with my permission, except as required by law.

The information collected now will be stored for a maximum of 3 months, from the day you have shared it. The information you provide will be stored securely and your identity will be kept strictly confidential, except as required by law. To protect your safety, rights, wellbeing and dignity, all research in the University of East Anglia is reviewed by a Research Ethics Body.

This research was approved by the SCI S-REC (ETH2223-024, Faculty of Science Research Ethics Subcommittee). This study is organised by Vinicius Pereira, PhD researcher at University of East Anglia.

1. I consent to share my name and contact information *

   ◯ Yes

   ◯ No

2. I consent to the responsible researcher of this study to store my personal information for a maximum of 3 months, from the submission of the present form *

   ◯ Yes

   ◯ No

3. I consent to be contact by the responsible researcher of this study in the future, for the maximum time that my personal information is stored *

   ◯ Yes

   ◯ No

(ii). Initial email contact

Subject: Help Design Smart Futures – Workshop Invitation

Message: Dear [Name of Receiver], Hope you're having a nice beginning of 2023!

My name is Vini and I'm getting in touch because you have signalised interest in receiving more details about participating in the research study I'm organising.

This research study regards the development of smart home technologies and how participatory approaches can foster a fairer relationship between people impacted by using the technology and stakeholders involved in its development—building a Net Zero future that works well for everyone.

The study will have three phases, and you will be able to contribute in all of them. The first invitation is for you to take part in a workshop about the imaginaries behind the smart technology development, focusing on technologies developed for the domestic environment. Practical information can be found in the attached "Participant Information Sheet".

To thank you for your participation in this first workshop, you will be offered £45 voucher compensation (compensations will also be offered in the subsequent research phases). The workshop will be held at the Energy Systems Catapult office, in Birmingham City Centre. Transport compensations up to £30 will be offered to support your travel to the venue (further details on this will be provided).

If you are willing to take part, please select all the dates and times you would be available on the following poll: https://forms.office.com/e/VX7v4RD7it

Please, contact me If you have any questions

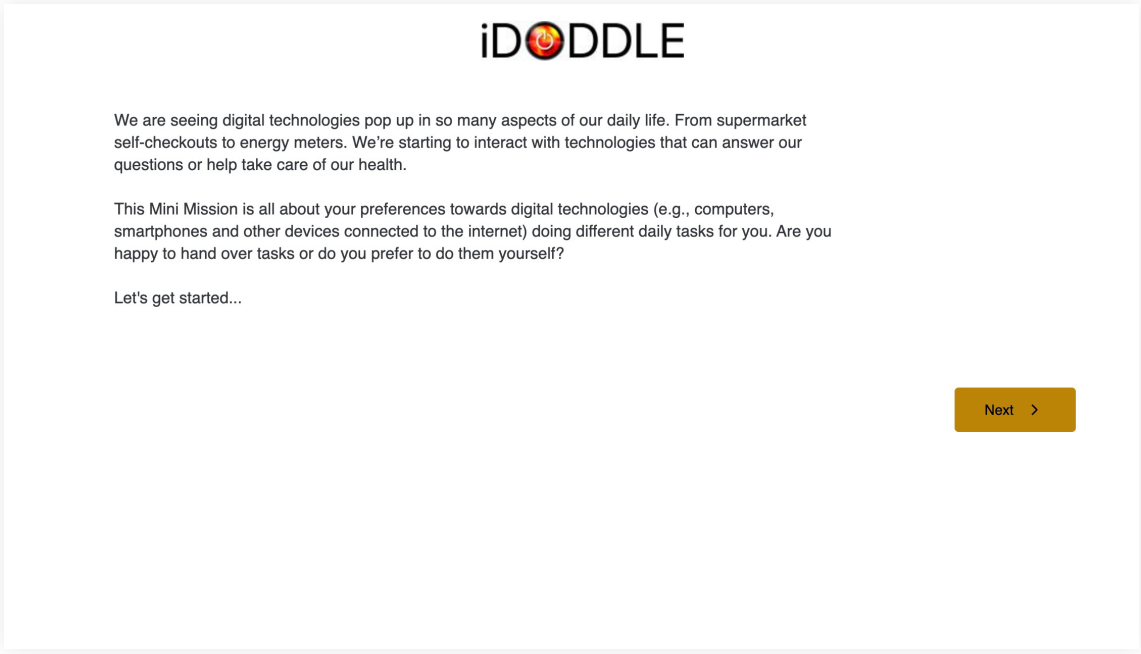
Thank you for your time!

Vini

Section 5. Late/Non-Adopters Recruitment

(i). iDoodle Mini-Mission

The following figures follow iDOODLE's short survey, or "Mini-Mission", monthly sent to participants of their Living Lab project. This mini-mission was used to recruit late-adopters and non-adopters of smart home technologies.



iDODDLE

Select the option that corresponds to your preference for the following tasks.

	Happy for digital technology to learn preferences, choose and perform the task on my behalf	Happy for digital technology to learn preferences and recommend actions	Prefer not to use digital technologies for this task	Not applicable
Turning home heating on/off	○	○	○	○
Arranging medical treatment	○	○	○	○
Responding to my emails	○	○	○	○
Buying new clothes	○	○	○	○
Playing a movie/episode to watch	○	○	○	○
Doing grocery shopping	○	○	○	○
Creating online content (e.g., for a social media profile or webpage)	○	○	○	○

< Back Next >

iDODDLE

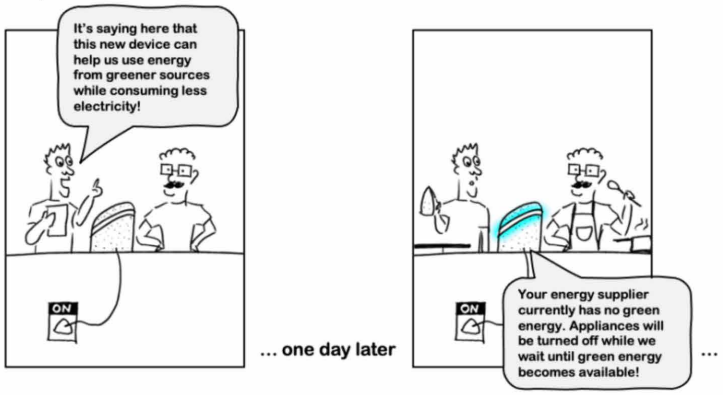
Select the option that corresponds to your preference for the following tasks.

	Happy for digital technology to learn preferences, choose and perform the task on my behalf	Happy for digital technology to learn preferences and recommend actions	Prefer not to use digital technologies for this task	Not applicable
Driving to visit friends/family	○	○	○	○
Preparing a cup of tea/coffee	○	○	○	○
Booking travel tickets	○	○	○	○
Paying household bills	○	○	○	○
Turning home lighting on/off	○	○	○	○
Turning washing machine on	○	○	○	○

< Back Next >

iDOODLE

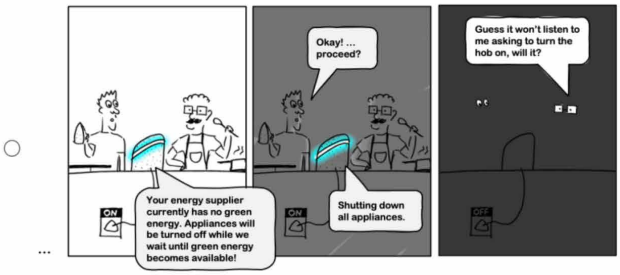
Please consider the following situation (you will need to zoom in if you are viewing on a mobile phone):



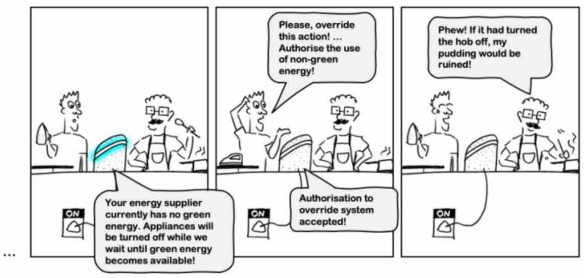
Back Next

iDOODLE

Now select from the following two options how you would like the cartoon to end (you will need to zoom in if you are viewing on a mobile phone):

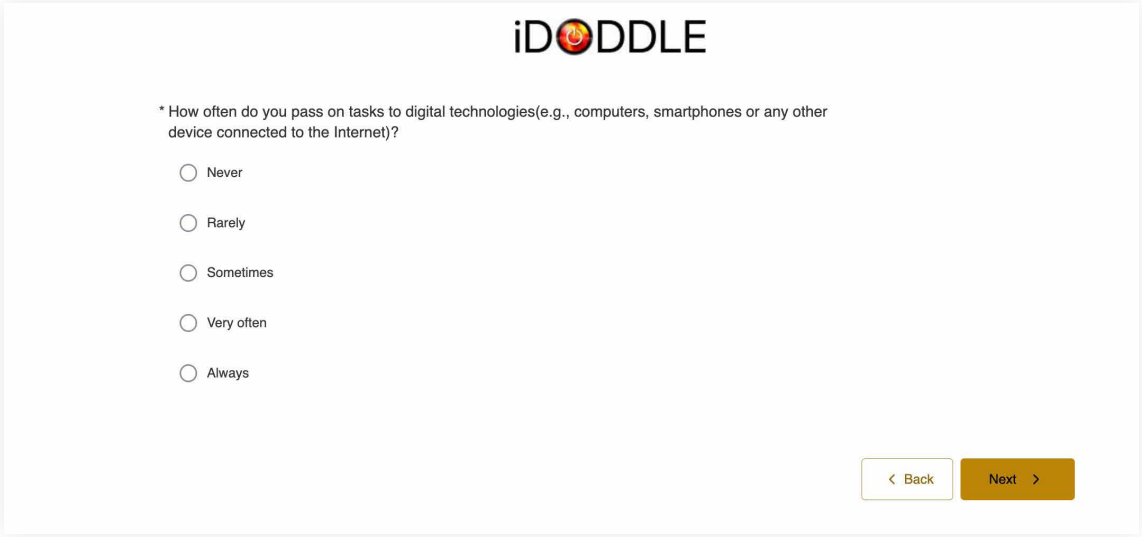


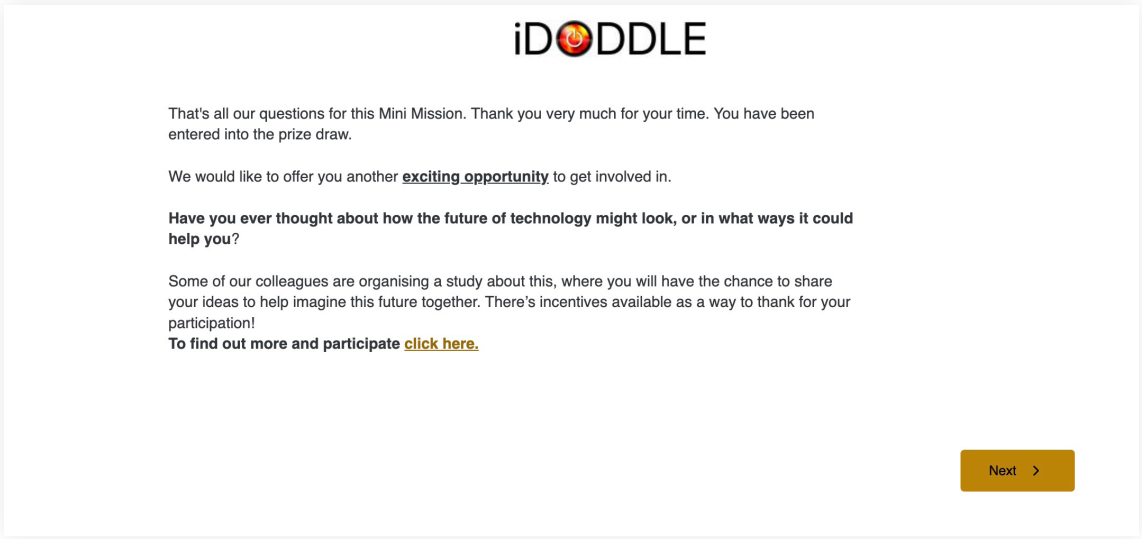
A. I'm happy to wait for green energy availability



B. I'd override the system to use my appliances now.

Back Next


iDODDLE
* How often do you pass on tasks to digital technologies(e.g., computers, smartphones or any other device connected to the Internet)?
Never
Rarely
Sometimes
Very often
Always
Back
Next


iDODDLE
That's all our questions for this Mini Mission. Thank you very much for your time. You have been entered into the prize draw.
We would like to offer you another exciting opportunity to get involved in.
Have you ever thought about how the future of technology might look, or in what ways it could help you?
Some of our colleagues are organising a study about this, where you will have the chance to share your ideas to help imagine this future together. There's incentives available as a way to thank for your participation!
To find out more and participate click here.
Next

(ii). Online Consent Form

Help Design Future Technology

We are looking for people willing to share their ideas about the future with digital technology. To find out more click "Start Now"

* Required

Hello !

GECKO

My name is **Vini** and I'm a PhD researcher at the University of East Anglia (UEA), working on ways to design technologies that better account for the needs and values of it's users. As part of the GECKO project (https://gecko-project.eu/) I'm especially interested in technologies that we use in the home.

To do so, I'd like to invite you to take part in a series of workshops in Oxford!

Benefits in participating

Besides having a say on the future of technology, while in the study, you will be able to exchange insights with other participants, researchers and designers!

In addition, if you take part **in the first workshop**, you will be offered a **£45 voucher compensation** for your participation. Transport compensation of up to £30 will also be offered to support your commute to the workshop venue in Oxford!

You will be offered voucher and transport compensations after every workshop you decide to participate during the study!

Practical information for the first workshop:

- The workshop will be held at the **University of Oxford** (address and directions will be given later).

- **No specific skills or materials are required**. You just need to bring yourself!

- The time and date of the workshop will be settled between participants, **at your convenience**. The workshop should approximately take 2h, including coffee breaks and refreshments.

What are the workshops about?

The workshops will explore your past experiences and ideas about **digital technologies**. In a set of short and fun activities, we will talk about household **everyday life** and the **objects and technologies** that are part of it. We will also get around popular themes like "artificial intelligence" and "automation", understanding what they are and how some people have it in their homes. The aim is for us to imagine together a more sustainable and fair future with technologies!

No need to be put off by these techie words! No skills or knowledge are required for you to participate — only your interest and imagination!

After being part of the first workshop, you will be invited to continue participating in the study in upcoming workshops, with extra benefits!

Your participation is important for us!

You are receiving this invitation because we consider that you can play an important part in helping to design future technologies that not only do good but that also accounts for inequalities and prejudices!

1

Are you willing to participate? *

- ◯ Yes, I want to take part!
- ◯ Maybe, I want to know more
- ◯ No, I'm not interested

Extra details with the "Participant Information Sheet"

Downloading the complete "Participant Information Sheet", you will get access to all detailed aspects of you taking part in this study.

To download click in the following link: **https://tinyurl.com/GECKOworkshop**

If you are still not sure about taking part, you can contact me: **v.pereira@uea.ac.uk**

2

Would you like to participate? You can always withdraw at a later point if you feel so

- ◯ Yes, I wanna try!
- ◯ Maybe, I want to email Vini first!
- ◯ No, I'm not interested

Consent Form

In giving my consent, I state that:

- I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.

- I have received the Participant Information Sheet, which I may keep, for my records, and have been able to discuss my involvement in the study with the researchers if I wished to do so.

- I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the iDODDLER Project, or at the University of Oxford, or at the University of East Anglia (or GECKO Project), now or in the future.

- I understand that I may stop participating in a workshop at any time if I do not wish to continue. I also understand that it will not be possible to remove my data unless the observation is videoed or I am individually identified in some way.

- I understand that the results of this study may be published but that any publications will not contain my name or any identifiable information about me.

- I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.

- I understand that this research was approved by the SCI S-REC (ETH2223-024, Faculty of Science Research Ethics Subcommittee).

Do you consent to:

3

Completing questionnaires ? *

- ◯ Yes
- ◯ No

4

Audio recordings during the workshops ? *

- ◯ Yes
- ◯ No

5

Photographs during the workshops ? *

- ◯ Yes
- ◯ No

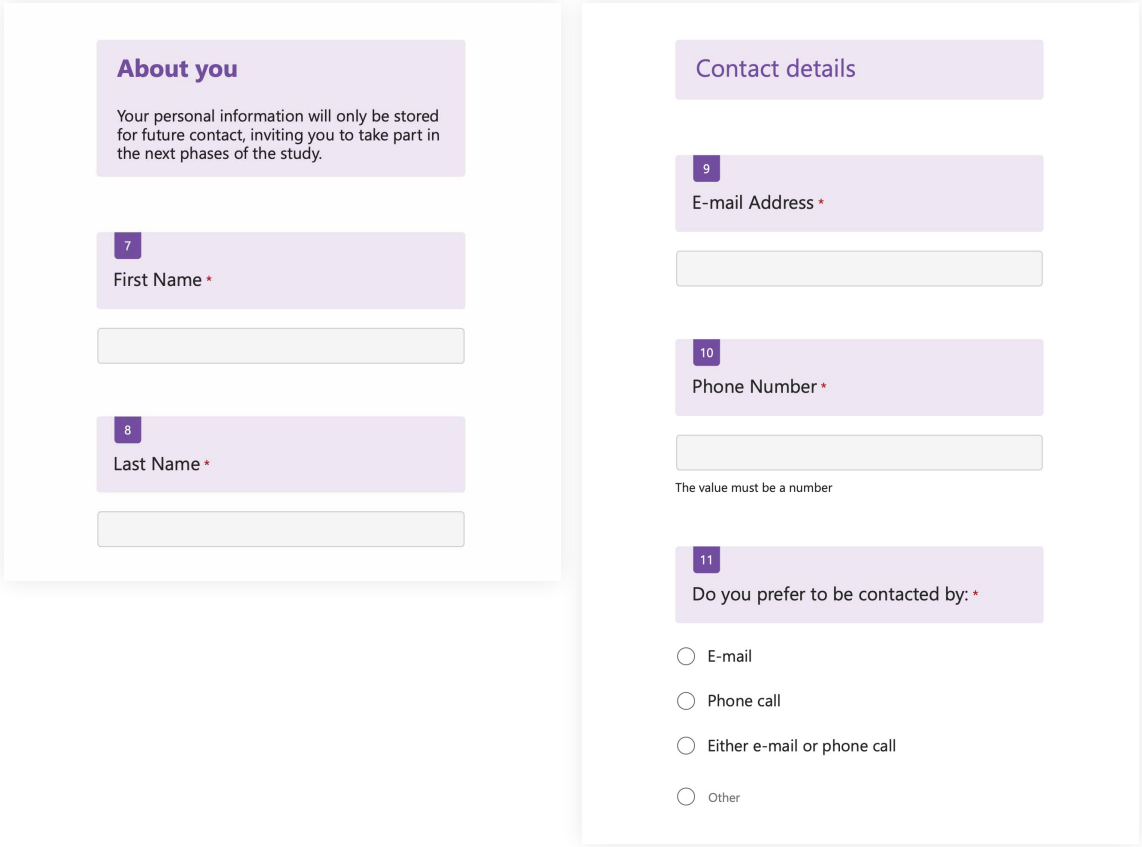
Data collected during the workshops

The data collected in this study may be deposited with an academic repository to allow it to be made available for scholarly and educational purposes, but the data will not contain my name or any identifiable information about me. The data will be kept for at least 10 years beyond the last date the data were accessed.

6

Do you consent to the data being **deposited in a repository?** *

- ◯ Yes
- ◯ No



(iii). Initial email contact

Subject: Help Design Future Technology

Message:

Hello there!Thank you for your interest in participating on this study from GECKO!

Now, we just need to organise a date for our first workshop.

Please click on the following link and you will be able to select all the dates and times you are available:

https://doodle.com/meeting/organize/id/bqlQ9m3a

For taking part in this first workshop, you will be offered a £45 voucher plus a compensation of up to £30 to support your commute to the workshop in Green Templeton College at University of Oxford!

I will soon send through the workshop agenda and attendance details.

Thank you for your time and see you soon!

Vini

Section 6. Voucher Compensation According to Attendance

	Alias	Phase 1: In-person workshop*	Phase 2: In-person workshop	Phase 3: Online Focus Group	Phase 4: Online Interview	Total/ Participation
Professionals	P1	£10	£45	—	—	£55
	P2	£10	—	—	—	£10
	P3	£10	—	—	—	£10
	P4	£10	£45	—	—	£55
	P5	£10	£45	£25	£10	£90
	P6	£10	£45	£25	£10	£90
	P7	£10	—	—	—	£10
Early-Adopters	A1	£45	£45	—	£10	£100
	A2	£45	£45	£25	£10	£125
	A3	£45	£45	—	—	£90
	A4	£45	£45	£25	£10	£125
	A5	£45	£45	—	—	£90
	A6	—	£45	£25	£10	£80
	A7	—	£45	—	£10	£55
Late/Non-Adopters	N1	£45	£45	—	£10	£100
	N2	£45	£45	—	£10	£100
	N3	£45	£45	£25	£10	£125
	N4	£45	£45	£25	£10	£125
	N5	£45	—	—	£10	£55
	N6	£45	£45	£25	£10	£125
	N7	—	£45	£25	£10	£80
	N8	—	£45	—	—	£45

**Professionals were offered a lower rate voucher as a compensation as the workshop was included in their payable working hours at Energy Systems Catapult.*

Table 9.2 - Voucher Compensation According to Attendance

Appendix C. Data Collection Instruments & Graphics

Section 1. Phase 1: Exploratory Workshops

(i). Workshop Programme

Duration: 2h30(max)

Aims & Scope: The set of visual representations or public discourses about a specific matter, that a person has seen, heard, or read, is responsible to organize that person's imaginary around that specific matter. Here, we aim to access imaginaries behind technologies that are currently available, focusing on smart technologies developed for the domestic environment. This workshop is part of a PhD research project that intends to contribute to a transition towards a more responsible and just smart home technologies' industry. During the workshop, participants will be presented to audio-visual inputs (e.g., photos, short videos, image cards, etc.) as activators of their current perceptions and experiences of smart home technologies. The mediator will give tasks and questions, proposing for the participants to rearrange the audio-visual inputs, writing down perceived values and feelings around their perception on smart home technologies. After the activity, a feedback form will be collected.

Programme:

(10 min) **Introduction** – greetings, workshop agenda explanations, initial talk about the subject, initial Q&A.

(25 min) **Task #1: Warm up (w/ background audio)** – using opaque glasses while listening to household audio playback, participants will touch and manipulate house objects with their hands (10 min). After that, without the glasses and not seeing the objects, they will be asked to recall a house they current live/they have lived before and imagine one of the rooms in that house, describing that room in a piece of paper. Then, they will describe an activity that they would do in this room (15 min). The paper will be folded and placed at the tote bag.

A) Give the name of the room.

B) Describe the following characteristics of the room: ***shape*** *(e.g., round, squared, rectangular...);* ***size*** *(e.g., is it big or small?); how do you* ***feel*** *when you were there (e.g., Embraced? Cozy? Bored? Excited?)*

C) Describe one thing/activity that you used to do/usually do there. Pay greater attention on mentioning the objects you use during the activity.

(25 min) **Task #2: House typologies** – a set of popular house typologies, showing to participants a generic set of aesthetics and design solutions. Participants will be inquired with a set of questions, and they should answer them by placing a colour sticker at one of the archetypes. Possible questions would include:

Sticker Colour	Question
	Which one looks like the safest?
	Which one would better protect your privacy?
	Which one would waste less energy?
	Which one looks like the most comfortable?
	Which one would provide more convenience to an everyday life?
	Which one looks more exciting and entertaining?
	Which one would better support your health and wellbeing?
	Which one is a smart home?

Table 9.3 - List of questions regarding the external look of the residential buildings in the second activity.

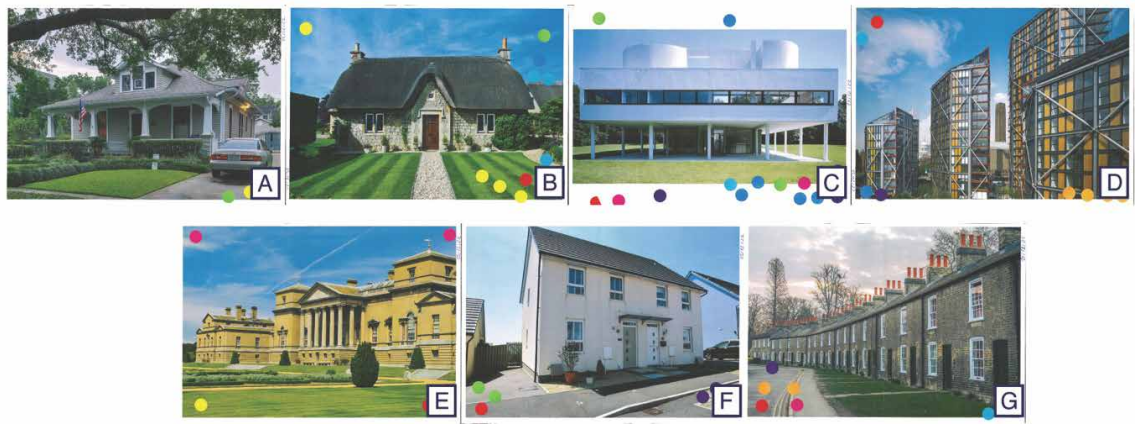


Figure 9.1 - Pictures showing seven typologies of ordinary British residential buildings: bungalow (A), cottage (B), detached house (C), flat (D), manor (E), semi-detached (F), terraced (G).

(30 min) **Task #3: Smart objects (w/ background audio)** – the papers of #1 Task will be sorted between participants. Each participant will identify the room described in the sorted papers and, possibly using the objects indicated, will turn the activity performed in that room into "smart". Participants will be asked to draw/collage/write this Smart Room, using a set of printed textures, coloured paper, and other materials available.

(10 min) **Coffee break**

(30 min/3 min each) **Task #4: Smart home** – participants will be asked to assemble a smart home with their individual rooms. One at a time, they will read out loud the first description of Task #1 and explain how they have turned that into a "smart room",

showing their representation of it. At the end of each talk, they should place the “smart room” in a kraft canvas, collectively assembling a smart home (indicating connection between rooms, staircases, windows, entrance, etc.).

(5 min) **Closing** – wrap up the activities and how they are related to their current imaginary of domestic life and smart homes, Q&A, acknowledgements.

(5 min) **Feedback form**

(ii). Household Objects

Figure 9.2 - Collection of household objects used in Phase 1 workshop.

Section 2. Phase 2: Descriptive Workshops

(i). Workshop Programme

Duration: 2h30(max)

Aims & Scope:The focus of the workshop is to provoke critical reflections about current smart home technologies (SHTs). And, used as a reflexive practice, a co-design process will be employed to produce alternative futures where current troubles are taken care of — instead of solving a "close-ended/tamed problem" with a technical "solution/reductive approach".

For that, the workshop will provide design and crafting tools, along with strategies to make co-designers (low-users, users, and experts) feel open to describe together alternative futures with SHTs. Responding to possible conflicts identified in the first round of workshops (current imaginaries), as well as to global climate and technology challenges, a design process will be facilitated by the researcher, conducting co-designers from (1) empathizing with their peers' individual values and global ethics/virtues, using them to (2) identify troubles in the current smart home imaginaries, (3) defining ways to better frame and take care of them. At this point, they will start (4) ideating alternative ways of taking care of those troubles and the workshop will be wrapped up with a final (5) presentation of scenarios where the SHTs described are possible. The ideation process will ask from co-designers to respond to social, economic, and environmental challenges, incorporating and dealing with them in their alternative scenarios. Expected results/data shall be presented in both textual (e.g., creative writing, word cloud, audio transcripts etc.) and visual formats (e.g., image boards, collages, drawings, storyboards, AI generated images etc.). After the activity, a feedback form will be collected.

Programme:

(5 min) **Introduction** – greetings, workshop agenda explanations, recall the subject and what have been done so far, give a context diagram (where this workshop is located inside the whole data collection), initial Q&A.

Study recap: smart homes, first workshop, and co-design process.

Today is about designing an alternative future.

4 activities, with **challenges/buzzer**.

(25 min) **When you are at home, what do you value?** – divided in groups (3 to 4pp) or couples (2pp). Every co-designer will receive a form with 3 partitions in it (A, B and C). Every Group will receive a 2x2 matrix + sticky notes (1st to aim / 2nd to avoid / 3rd to transform / 4th to respect).

(5 min) **1. [Guarantee]** Co-designers will be asked to write down in the form 1 thing they value the most in their homes – could be a feeling they have when living their domestic life, or a practice they are able to do, etc.

(8 min) **2. [Avoid]** Facilitator will present three issues in smart home technology related to important topics for socio-environmental change (e.g., gender/sexism, privacy/ surveillance, racism, etc.). After that, they will be asked to write down in the form, 1 thing they want to avoid having to experience in their domestic life — prejudice, sexism, violence, harmful bias, etc.

(5 min) **3. [Transform]** Facilitator will present the effects of Climate Change, linking it to housing challenges that will also be faced, as describe by the United Nations. Co-designers will be asked to write down in the form, one thing that they would like to take care of/act on/help to transform.

(5 min) **D. [Prioritize!]** Co-designers will be asked to share within the group their first notes in the partitioned form. As a group, they will decide upon the 1 aim to prioritize, 1 thing to avoid, and 1 thing to transform.

(2 min) **E. [Respect]** The first tension/buzzer/wild card moment, co-designers will be shortly introduced to the Feminist Tech Principles (by SUPERRR Lab), and they will draw a card containing a principle that should be respected by new/alternative smart home technologies.

(20 min) **Defining troubles** – (10 min) Facilitator will present the conflicts between the first workshops and definitions of SHTs found in literature (could be around "how is an ideal smart home" or "smart home challenges", including the understanding that any residential unit could be, at some extension, be designed to be/transformed into a smart home). That will compose a diagram of troubles/conflicts/limitations found in current imaginaries of smart home technologies. **[Troubles]** After some deliberation and facilitator round with groups, each group will agree/choose on one "Trouble" found in the current representations of the smart home (can be technical, theoretical, ethical, economical, philosophical, etc). The chosen "Trouble" should be of the interest of the group, either personal/professional interest or empathetic/altruist to affected communities. They will write that down in a card and place with the 2x2 matrix.

(5 min) **Short break/refresh**

(45 min) **Ideating ways/technologies to take care of the troubles** – Brainstorming ideas of how to construct what is being imagined that could incorporate the 2x2 matrix. The researcher will walk around the groups, helping them to represent/draw/prototype what they are trying to do. There should be a constant discussion on how this thing being designed is integrated in the imagined alternative reality they have envisioned (the scenario where this thing exists). After crafting the thing, they should have some form of prototype (if it's an artefact, should be a physical model, if it's a service, could be a storyboard/cartoon or app wireframes, if it's a governance/policy should be in a text format).

Make sure they understand that what they are designing should have a responsible and just impact in all the fields it could possibly reach.

[How the world you're designing for looks like?] Second buzz, still seating in groups they will be asked to think about the world/surroundings where the thing being designed exists. What does it look like? What group of people or population is being impacted? In which ways?

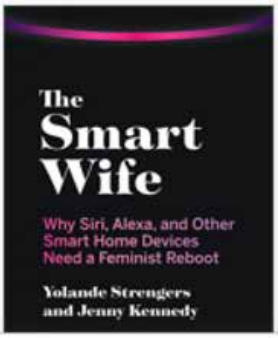
(10 min) **Coffee break**

(20 min/5min for 4 groups of 3pp/each) **Presenting** – Each group will have 5 minutes to present their final design along with the scenario where this solution would inhabit. They will conduct us from the proposed desirable scenario, with the list of problems and solutions, identifying the solution proposed, its requirements, and finalising with the ethics canvas.

[The Tarot Cards of Tech (by Artefact)] Drawing one or two cards from the Tarot Cards of Tech during the wrap up presentation. They will read the question posed by the card and answer as a group.

(5 min) **Feedback form**

(ii). Supporting Slide Deck



'Smart' tech is being weaponised by domestic abusers, and women are experiencing the worst of it

Coco Khan

Access to doorbells, heaters and watches means that vindictive partners can control and torment wives and girlfriends

Tue 4 Apr 2023 10.00 BST

Smart home tech is being turned into a tool for domestic abuse

Smart doorbells and thermostats are an emerging trend in domestic abuse, but those working on the front line lack the tools and know-how to fight back

By WIRED 22.07.2018 07:00 AM

The internet of things has opened up a new frontier of domestic abuse

John Naughton

As most digital devices are installed by men, it is former partners, not hackers, who pose the greatest threat to women's welfare

Your voice assistant might be racist for one troubling reason — study

March 23, 2020

Not only might your smart assistant be listening to you, it is also probably racist for this one disturbing reason.

Automated speech recognition systems, like the ones operating voice technologies like Amazon Transcribe and Apple's Siri, understand black people less than they understand white people.

Discriminatory pricing

Exploring the 'ethnicity penalty' in the insurance market

citizens advice

Tilly Cook
Aiden Greenall
Emer Sheehy

"Studies have discovered indications of unequal outcomes for individuals with protected characteristics in the insurance market in recent years. As markets change and the use of "big data" and algorithms in price-setting becomes more widespread, there is a danger that **these disparities will be perpetuated and intensified.**"

Smart devices and the fight against climate change

Justine Calma Apr 5, 2022 at 7:27 PM GMT+1

Smart devices have a role to play in the move from dirty to clean energy, according to a major new climate report released this week. People need tools that help them better understand where their energy comes from, see how much they're using, and pitch in to make a more resilient power grid.

"Digital technologies can contribute" to the fight to stop climate change, the report released yesterday by the United Nations Intergovernmental Panel on Climate Change (IPCC) says. That contribution can include smart appliances that make homes more energy-efficient or rooftop solar panels that work in tandem as "virtual power plants." Those technologies have the power to cut down greenhouse gas emissions and transform the electric grid.

Smart energy stumped by 'rebound effect'

Engineers figured out clean energy. But they can't engineer human behavior.

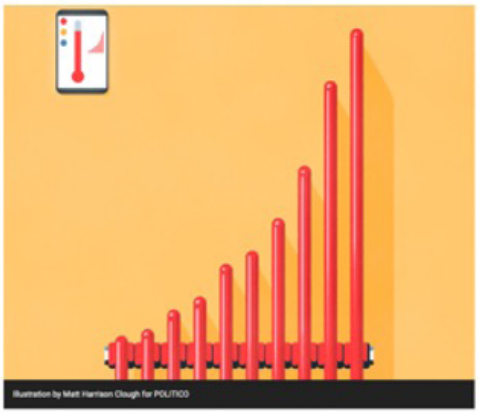


Illustration by Matt Harrison Clough for POLITICO

BY ANCA GURZU

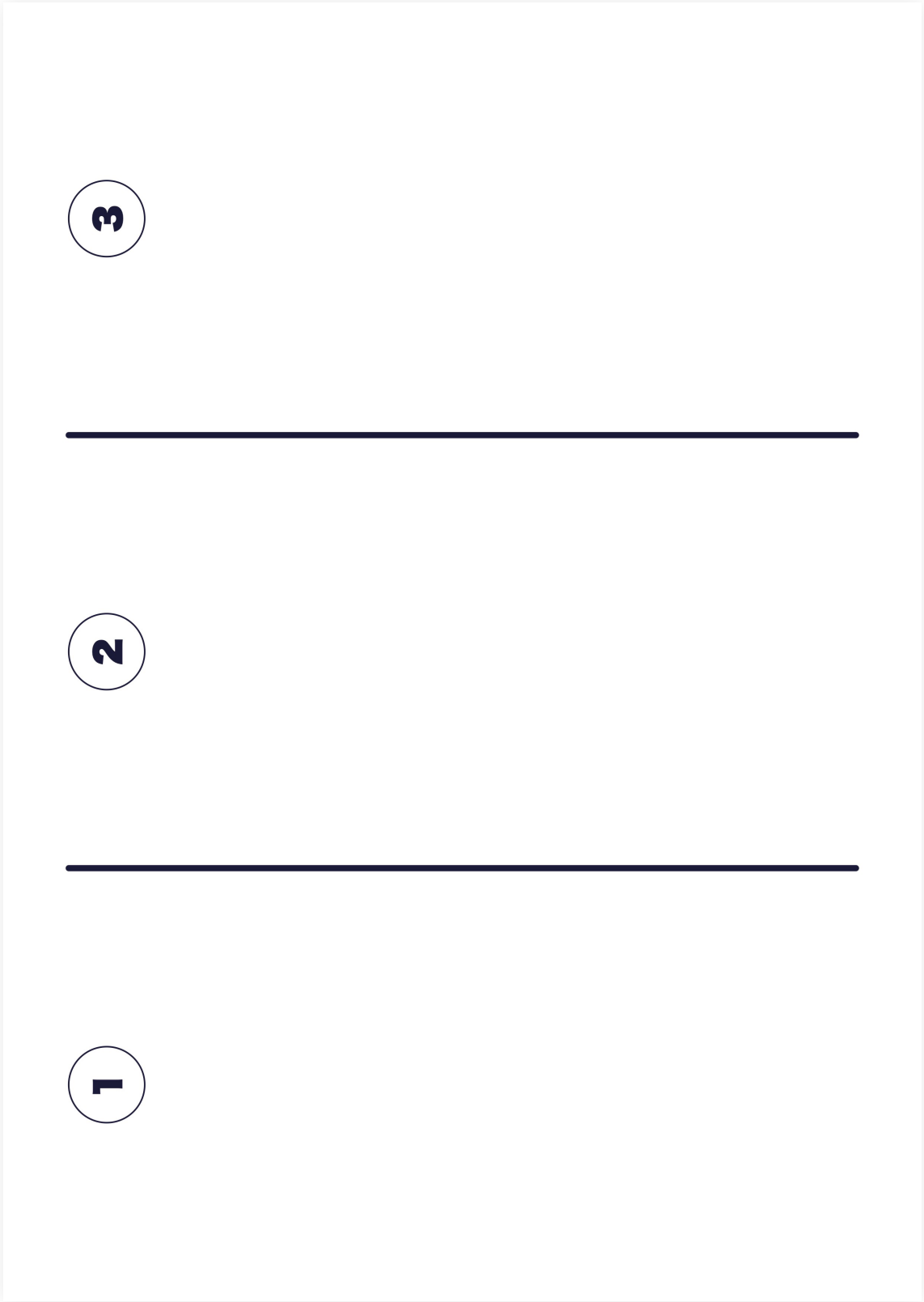
MAY 24, 2017 | 10:00 AM CET | 5 MINUTES READ

Based on various UN sources

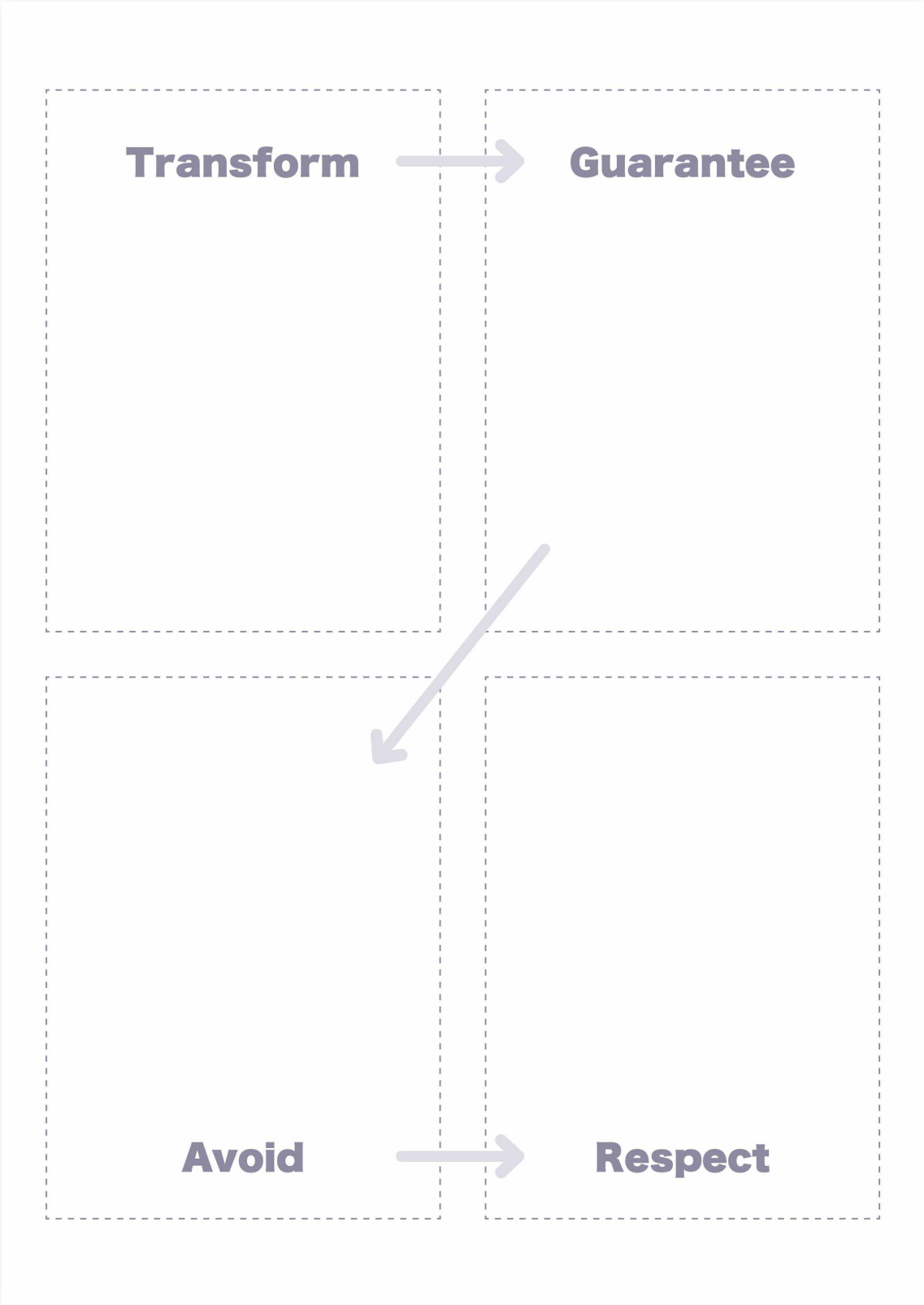
- Hotter temperatures
- More severe storms
- Increased drought
- A warming, rising ocean
- Loss of species
- Not enough food
- More health risks
- Poverty and displacement

- Increased Risk of Inclement Weather Events
- Rising Homeowner Costs
- Increased Building and Material Prices
- Reduced Indoor Air Quality
- Lack of Available Housing

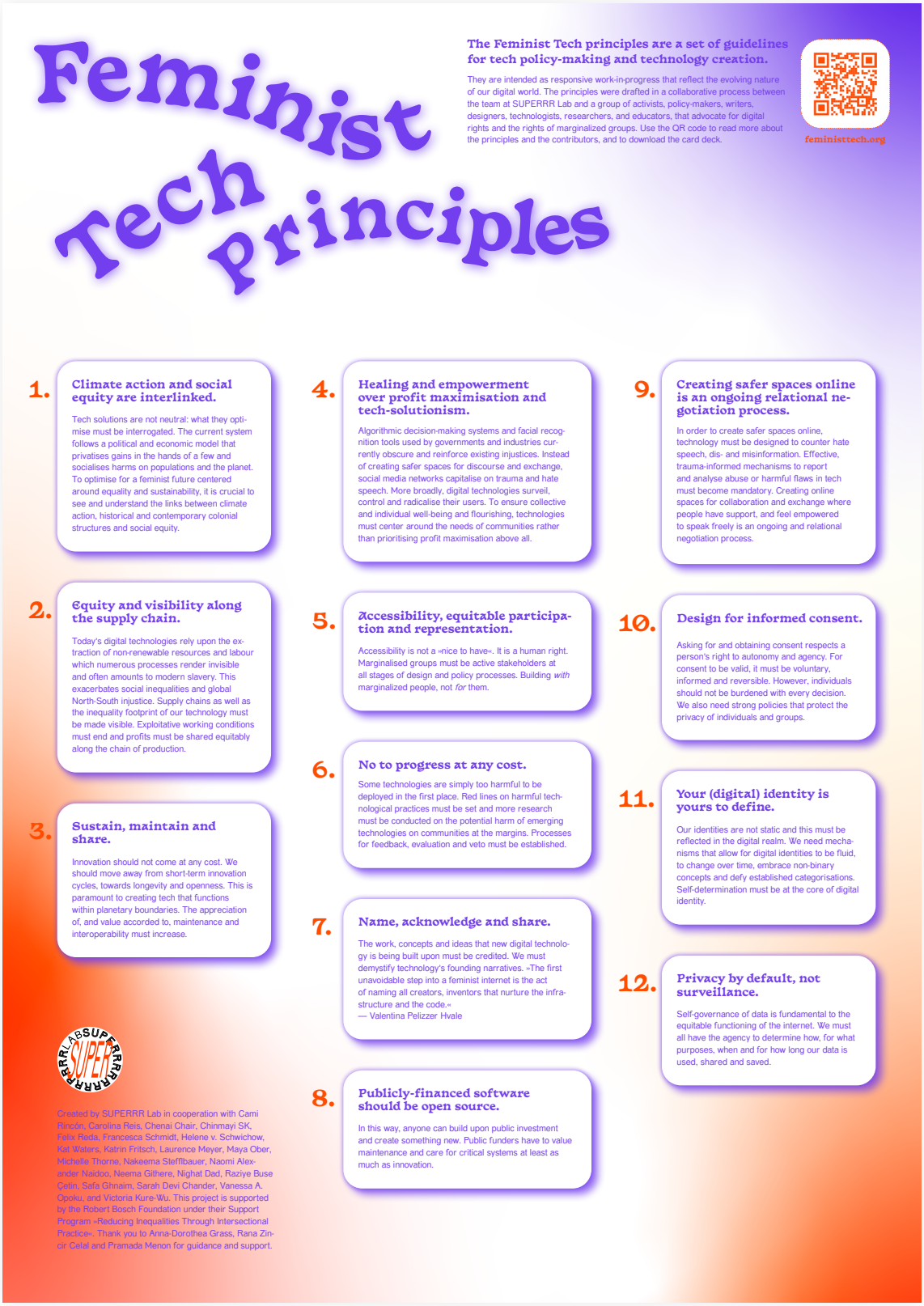
(iii). Individual Priorities Template



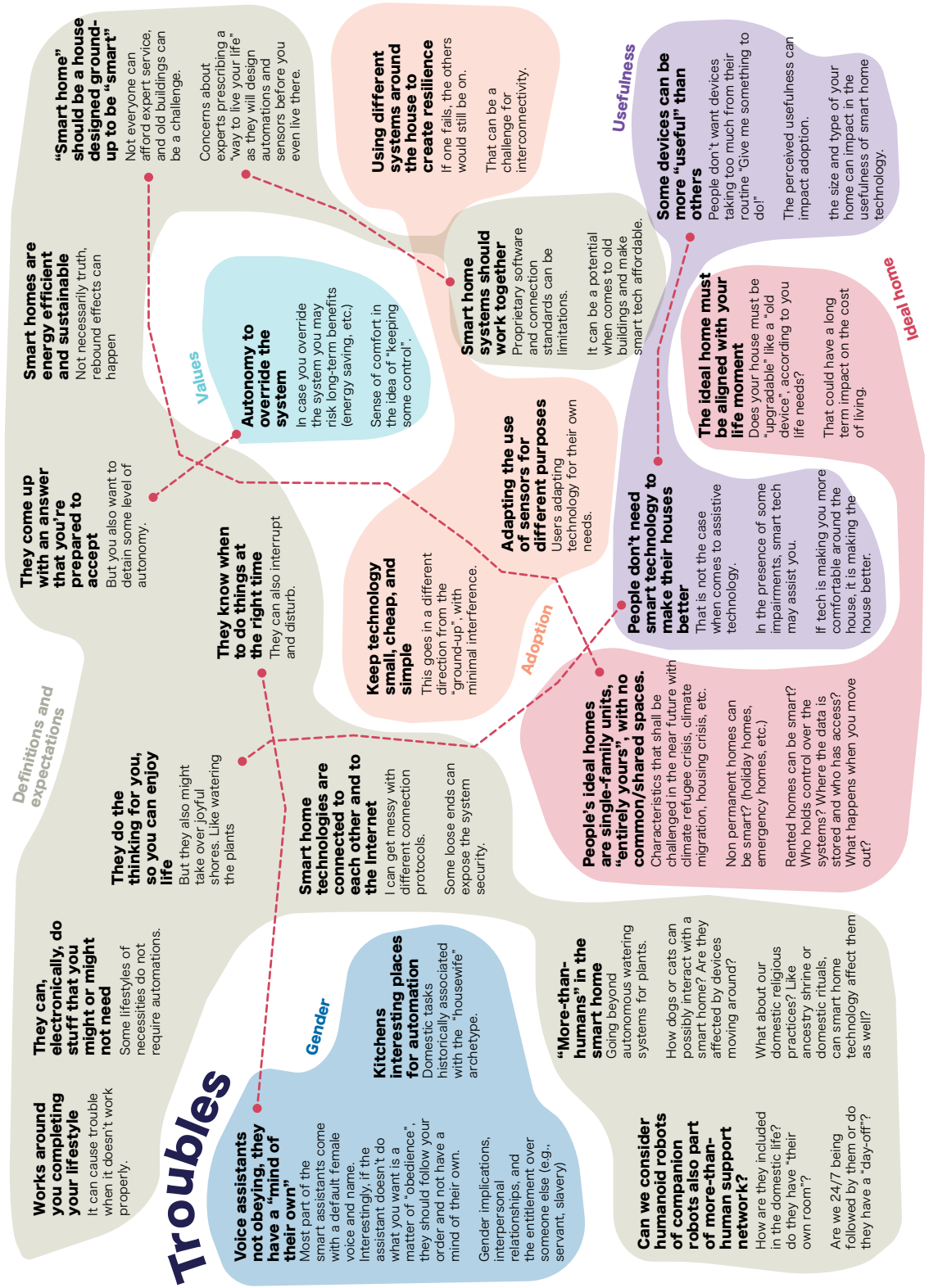
(iv). Matrix of Priorities Template



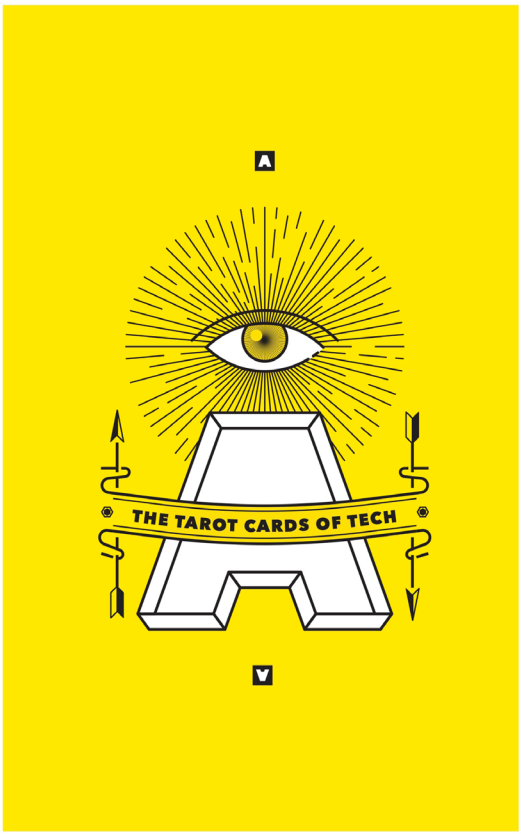
(v). Feminist Tech Principles



(vi). Troubles Diagram



(vii). The Tarot Cards of Tech

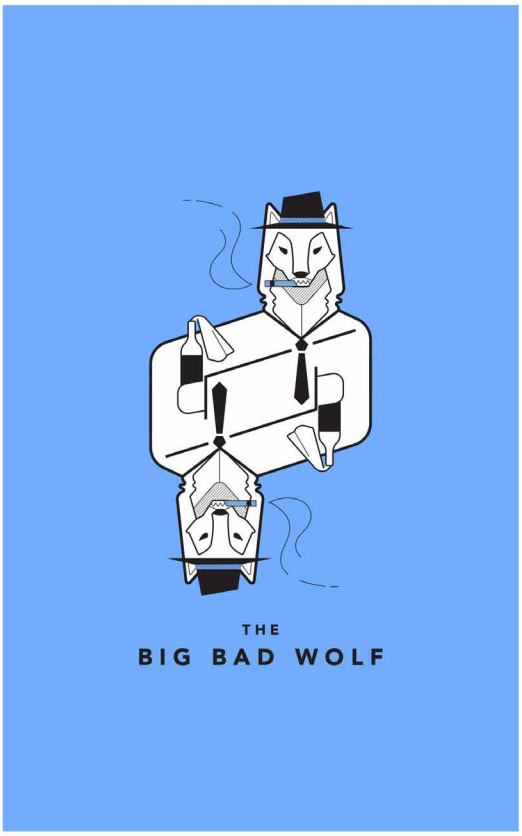


Artefact created The Tarot Cards of Tech to help creators of all kinds consider the impact of technology.

Each card contains provocations that will not only help you foresee unintended consequences, but also reveal opportunities for creating positive change. Take The Tarot Cards of Tech to your next brainstorm or team meeting to gaze into the future and better understand the potential impact of your products.

If you like these cards, let us know at info@artefactgroup.com.
From workshops to design thinking, Artefact would love to learn how best we can help you and your organization.

www.artefactgroup.com



THE
BIG BAD WOLF

What could a "bad actor" do with your product?

What would predatory and exploitative behavior look like with your product?

What product features are most vulnerable to manipulation?

Who could be targeted with your product?

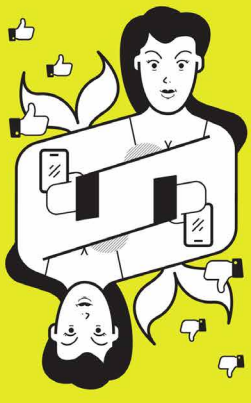
THE
BFFs

THE
BFFs

If two friends use your product, how could it enhance or detract from their relationship?

How does your product change or create new ways for people to interact?

Does your product fill or change a role previously filled by a person?



THE
SIREN

THE
SIREN

What would using your product "too much" look like?

How does your product encourage users to engage, and how does it make it easy to disconnect?

How does your product respect people's boundaries and the other parts of their lives?

In what situations might it be inappropriate or distracting to use your product?

Section 3. Phase 3: Prescriptive Focus Group

(i). Focus Group Instrument

Duration: 1h30 (max)

Aims & Scope:Prescriptive focus group to understand key changes between Phase 1 and Phase 2, mapping a "transition pathway". A prescriptive and analytical approach divided in two moments. The first, focus group discussions identifying key changes in the current sociotechnical imaginary (RG1), assisting the transition towards the sustainable and responsible user interactions scenarios (RQ2). Then, in a second moment, alongside the feedback forms from RQ1 and RQ2, a series of evaluative interviews will be conducted to analyse the present co-design process, understanding participant's perception and engagement. Expected results would mainly be composed of texts with discussions' transcripts and possibly explanatory diagrams or illustrations with examples brought up by participants. Researcher's Takeaway: list of things that needs to happen in every transitional system level (landscape, regime, niche), mapping the "synergistic interventions" or "granular actions" between each level. Can we position the designs as niche interventions? Participants' Takeaway: feeling comfortable and empowered in making more responsible and just decisions towards the use or design of smart home technologies. Make them understand that a transition happens in different levels, and that connecting social justice is a responsible way to steward the transition pathway. Design guidelines and practical examples to support the development of sustainable and responsible user interactions of smart homes technologies, discussing its implications. An evaluation of the undertaken co-design process, discussing its methods and applicability in future research around smart home technologies.

Programme:

(10 min) **Meeting dialling-in tolerance**

(10 min) **Introduction** – greetings, agenda, "say you name and what you remember from the last workshop?", recall the subject and what have been done so far, initial Q&A.

(30 min) **Discussion** – This first part of the discussion we will talk about the upper levels of sociotechnical transitions (Landscapes and regimes). Recalling the prep content, we will be able to add up other possible things that should/could happen to enact regimes that can transcend into landscapes.

(5 min) **Break**

(25 min) **Discussion** – The second part of the discussion we will talk about the lower level of sociotechnical transition (niches). Recalling the niche design from the last workshop, collecting reactions and perceptions about the possible use of the things designed. Guiding the discussion to an end.

(ii). Fictional Advertising

(iii). Fictional Podcast

Section 4. Phase 4: Evaluative Interviews

(i). Interview Instrument

Block 1: Warming up	
Q1	*Can you remember how you got to know about this co-design study?*
Q2	*Could you describe the study in your own words?*
Q3	*Taking part in the workshops and discussions, did it make you think differently about technology in general?*
Q4	*After taking part at the workshop(s), how do you feel about the following statements?* *Smart home technologies can make your life easier, just doing things for you so we all can enjoy our lives without thinking.* *My house doesn't need to be smart. It is nice as it is. I look at that and think "I don't want to put smart technologies in it". If it's a happy space in a home, then it doesn't need much.*
	Comments: The subject I brought to discussion was the smart home and its technologies. In the workshops we were able to explore from how we understand this kind of technology today, and to imagine how this kind of technology could be in the future.
Block 2: Co-design process & structure	
Q5	*How did you feel when I proposed the activities and exercises that we did?*
	Comments: About "Active participants".
Q6	*Can you recall any moments where you felt there was little or no space for you to share your own experiences?*
	Comments: We've had people sharing their experiences throughout the process, from personal life to work life, teaching us and adding up to the discussion. About "Social practices or value-led" and "Mutual learning".
Q7	*When comes to making decisions during the workshops, in what ways you believe you were able to influence the group?*
	Comments: During the workshops we've had a mix of individual and group activities, and almost in all of them we also had a collective conversation. About "Shared decision power".
Q8	*In which moments, if at all, did you feel that having the support of visual representation or prototypes helped you to communicate your ideas with others?*
	Comments: We have been through a design study, which means that most part of the activities we did are based on visual representation. About "Design tools".
Q9	*Could you mention something you have learned during the workshops?*
	Comments: The intention with the workshops was that I'd bring a discussion subject and together we would branch it out, exploring the topics using design techniques. It's common for this kind of meetings to allow knowledge exchange between people involved. About "Mutual learning".
Q10	*About the general structure of the study, what aspects would you modify to make it more relevant/engaging/useful for you?*
	Comments: The structure proposed for our co-design process consisted of three separated phases, with in-person and online workshops. We've also had some space between workshops.
Block 3: Responsibility, justice, and impact	
Q11	*How do you see this process contributing for the development of smart home technologies?*
	Comments: What can we do next? What is the main contribution of the co-design?
Q12	*Considering the following statement, in which ways do you believe our co-design study was responsible or promoted responsibility?* *"Responsible innovation is a collective commitment of care for the future through responsive stewardship of science and innovation in the present." (Owen et al., 2013, p. 36)*
	Comments: Historically, innovations hold much more impact than their developers have been able to foresee. To avoid and govern possible harmful outcomes (and to direct innovation towards the desired benefits), there has been efforts in industry and academia to stablish a more responsible development of technology.
Q13	*Considering the following statement, in which ways do you believe our co-design study was just or promoted justice?* *"Design justice is a growing community of practice that aims to ensure a more equitable distribution of design's benefits and burdens; meaningful participation in design decisions; and recognition of community-based, Indigenous, and diasporic design traditions, knowledge, and practices." (Costanza-Chock, 2020, p. 23)*
	Comments: In our workshops we've talked about how technology can delivery lots of functions to help us, but we've also mentioned how these are not equally distributed, sometimes reinforcing social disparities.
Block 4: Closing	
Q14	*How would you summarise your participation?*
	Comments: Why was it worth? Any takeaways? Do you feel satisfied?

(ii). Feedback Form

Phase 1: Exploratory Workshop

Smart Home Technology Imaginaries

Feedback From

Please, respond to the following statements by using the 5-point rating scale to indicate the extent to which you agree or disagree with each statement. Please tick the number that applies

1. **Strongly Disagree**
2. **Disagree**
3. **Neither Agree nor Disagree**
4. **Agree**
5. **Strongly Agree**

a) I felt confident and engaged when doing the proposed tasks.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

b) My life experiences, memories and general knowledge have helped me when doing the proposed tasks.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

c) I was able to teach something or share a personal experience to other participants and/or facilitator(s).

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

d) I have acquired new knowledge and/or gained experience doing something that I haven't done before.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

e) While doing the proposed tasks, I was able to make decisions and/or influence a group decision.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

f) I was able to represent my ideas using visual means (e.g., drawing, sculpting, etc.)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Please, use this space if you'd like to add any thoughts, suggestion, or feedback about the workshop:

Please return this form to facilitators before leaving.

Thank you for participating in this research!

Appendix D. Data Analysis Process Examples

Section 1. Transcription Example

The following is an excerpt from the audio recording transcription of one of the evaluative interviews in Phase 4 of data collection:

Date: 16/10/2023

Location: Microsoft Teams

Key: R = Researcher / N2 = Late/Non-Adopter

R	*So let's start just trying to warm up a little bit. Can you remember how you got to know about this co-design study?*
N2	*Not exactly, but I would guess the iDoddle, I can't remember what the group is called and was there something on Instagram about it? Maybe back in the day, I think.*
R	*Yeah, I guess it would be through the mini mission, right?*
N2	*Yeah, I think there might have been mentioned there. I doubt it was Twitter. It almost certainly was something on Instagram that I responded to. I would have thought.*
R	*And could you describe the study in your own words, like the workshops that we did together?*
N2	*Describe the study. Well, I thought I was doing workshops with activities, creative activities designed to stretch our minds open as up to technology. So, you could record it all and laugh at us later. And draw some kind of conclusions. But God knows what kind of conclusions you would draw from some of the stuff we did.*
R	*Taking part in the workshops and the discussions that we had, did it make you think differently about technology in general?*
N2	*I'm just gonna try and find the volume and up your volume and did it make me think it. It has constantly made me think, umm, not just in the work the tail end, the legacy of the workshops has been each time I … each time, quite frequently, when I interact with something, be at my phone or the telly or the laptop, it's made me think about it a little bit more, but not in a kind. Well, so I'm doing something for one of you people with Netflix. I've had a Netflix subscription for three months and I'm gonna get quizzed at some point on how I feel about that. And so, each time I have fired that up. I have been thinking about the interface, and I used to do for the last 10 years that I was working, I was the user experience person … and so, I do think a lot about interfaces and stuff … anyway, but the workshops have made me think … well, talking to other people in them, there's one lady in particular who talked about the smart home and what it means for her to disabled neighbour or disabled friend, and from being quite anti the smart Internet enabled house. I can see the advantages for some people, it still doesn't appeal to me, but I can see the advantages and … I can't remember what it was. She outlines one specific thing the neighbour's house did, and I just thought it was mind-blowing that the technology could do that and help. I can't remember what it was. It wasn't that much though, but yeah. Going to the workshops has made me think more about technology. I don't think it's necessarily changed my opinion of some of it, but it has made me think a bit more about … I've enjoyed that aspect of it. I mean, there's like, the fun and games in the workshop and the interaction with other people. And then there's the legs of … the tail end of it, is like thinking on comfortably well after the workshops.*
R	*And I'm gonna show you two statements. I'll just share my screen and. Can you see statement A&B … if you have read, I'll ask you one thing after.*
N2	*OK. OK. Yeah.*
R	*So after being part of the workshops, how do you feel about each statement?*
N2	*Umm. Well, I agree with the first uh … part of the of uh … A. I have no direct experience, but I have heard how smart technologies can make life easier. Umm, but the just doing things for you so we all can enjoy our lives without thinking. Interesting thing "about without thinking", umm and I disagree with that … because I think some smart technologies are just … you don't need to think about what they're replacing … you don't need to think about it. You just do it and it's. I don't know it. OK, so immediately the word that was in the back of my mind that I didn't say out loud was "lazy". I think smart technologies can make you lazy, so there are said it … "my house doesn't need to be smart" again. I agree with the first part of that. "It's nice as it is" still in agreement. I look at that and think I don't wanna put smart technologies in it. Yeah, "if it's a happy space then it doesn't need much". Yeah. I mean, if you want me to align, you haven't asked, but I would say I … do I align? … I align with B more than A, although I acknowledge both are valid arguments that's sitting on a fence properly.*
R	*Yeah, that's alright. Uh, just out of curiosity, you said like in a statement B, you are responsible for everything from like "I look at that and I think" and till the end like, it's a quote from you.*
N2	*That makes sense to myself, I think.*

Section 2. Textual-Visual Analysis Examples

(i). Compositional Interpretation Questions

Guiding Questions	P1-PRO
Who made it?	*Professionals working with smart home technologies.*
What is being shown?	*A collective collage*
What are the components of the image?	*Seven A4-sized rectangles with drawings and text complementing the whole.*
How are they arranged?	*They are placed next to each other, not overlapping, with some placed vertically and some horizontally. The arrangement is related to their position in the imagined smart home. The image is also quite horizontally spread.*
What is its material form?	*It is a flat surface collage of A4 layout paper on top of a long brown kraft paper.*
Is it one of a series?	*No, this was the only representation produced by this group of people.*
Where is the viewer's eye drawn to in the image, and why?	*To the top-right area, where a big circle drawn on the paper represents a spiral staircase connecting the rooms in the house. In the same area, one of the A4 papers is in a contrasting pink.*
What relationships are established between the components of the image visually?	*There is a connection between each A4 rectangle, as they would be connected by elements such as doors or corridors. As they have been produced by different people in the same group, there's a sense of patchworking.*
What use is made of colour?	*Colour is mostly found in the use of printed textures to represent grass, gravel, wood, stone, tartan, and felt. Two A4 rectangles were made using coloured paper, so the whole room is in dark green and pink.*
What is, or are, the genre(s) of the image? Is it documentary, soap opera, or melodrama, for example?	*the representations are both documentary (in a sense they present a clear and straight information on what things would compose the room), but also a non-fictional narrative (in a sense that they would image a way or journey one would make while using that room).*
To what extent does this image draw on the characteristics of its genre?	*The representations are mostly in a top view/architecture plan layout view, which is quite common for documenting houses and buildings.*
Does this image comment critically on the characteristics of its genre?	*There are an exaggeration of electronic elements in the representations, indicating how far one could go with house automation. There is also the presence of pets and gardens, clearly referencing to the life one would pursue inside those rooms.*
What do the different components of the image signify?	*As a whole they are meant to be a smart home, and each component is a smart room: two living rooms, one outdoor toilet, one bathroom, one bedroom, two kitchens with dining area.*
What knowledges are being deployed?	*Producers have used their personal and professional knowledge of houses and everyday life as all being white middle-class European.*
Whose knowledges are excluded from this representation?	*Shared living arrangements, council/social housing, living with health-related conditions, disabilities or reduced mobility, non-white and non-European, also lower or upper-class living standards.*
Are the relations between the components of this image unstable?	*No, they form a cohere collage.*
Is this a contradictory image?	*No.*
Who were the original audience(s) for this image?	*Researcher and peer participants in a workshop.*
Where and how would the image have been displayed originally?	*During a workshop, in a group activity.*
Who are the more recent audiences for this text?	*Other researchers and science dissemination channels.*
Would the image have had a written text to guide its interpretation in its initial moment of display, for example a caption or a catalogue entry?	*Yes, each image has written indication for the name of the room, and also furniture or appliances present in the room.*
Is more than one interpretation of the image possible?	*Even if the isolated collage not necessarily indicating a smart home, looking at the written indications one would approach the idea of automation and household rooms.*

(ii). Graphic Analysis Example

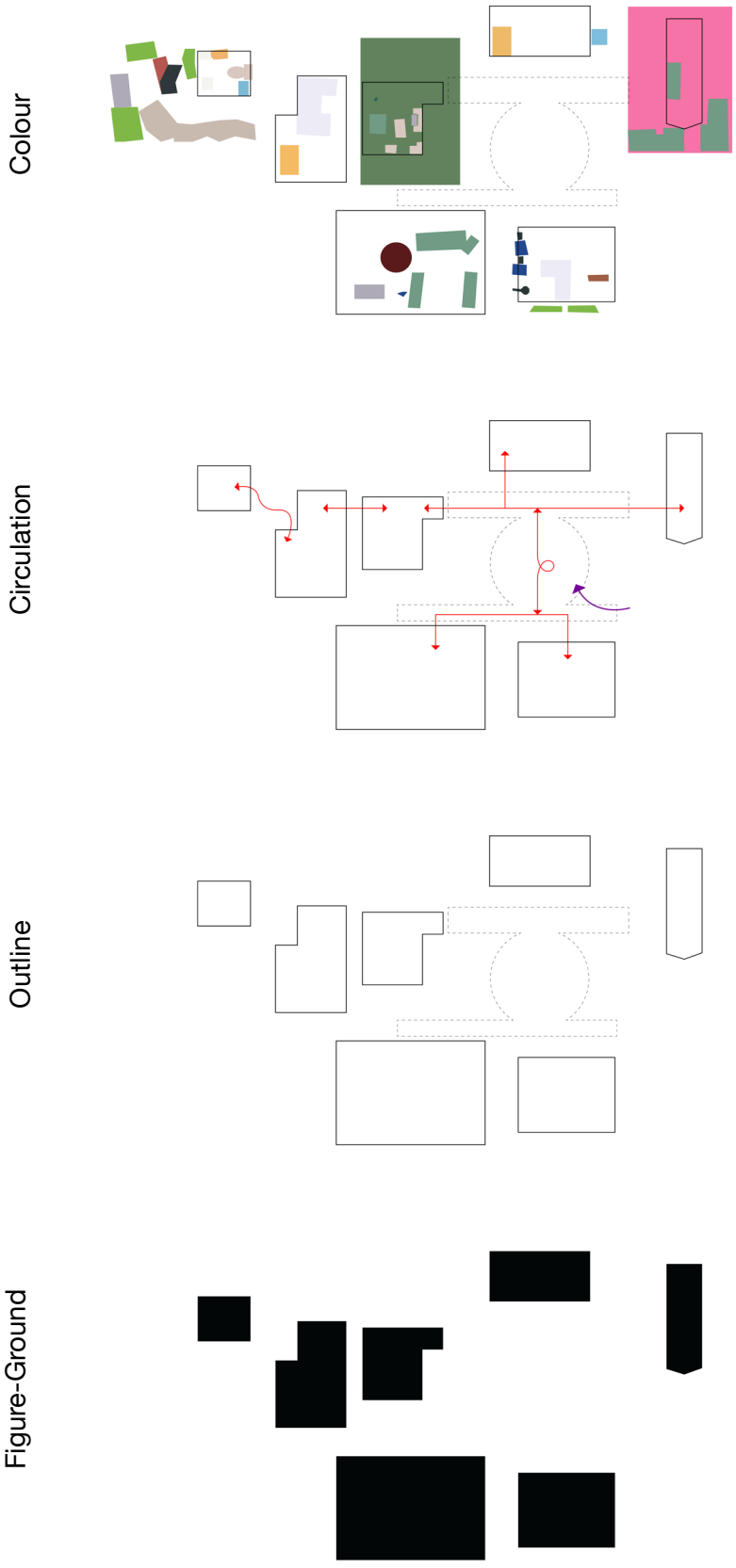


Figure 9.3 - Graphic analysis of Professionals' smart home.

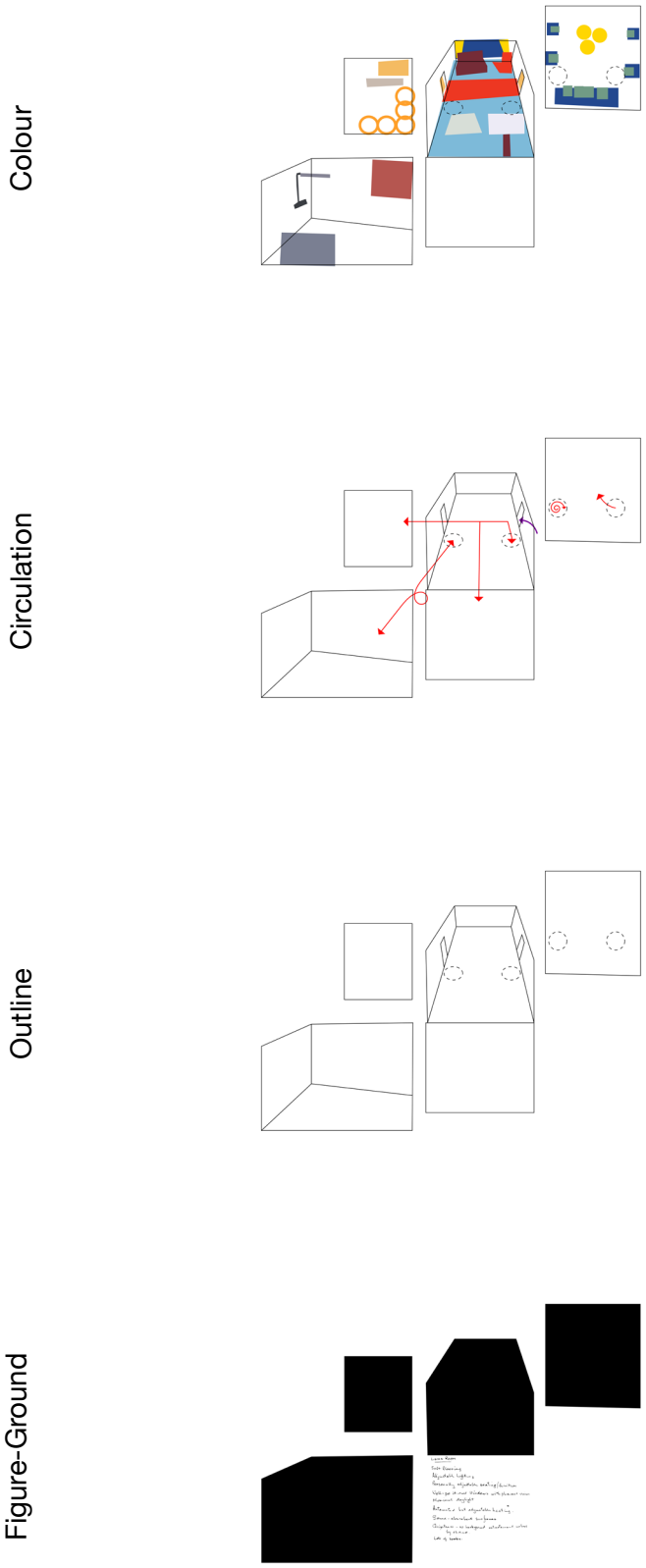


Figure 9.4 - Graphic analysis of Early-Adopters' smart home.

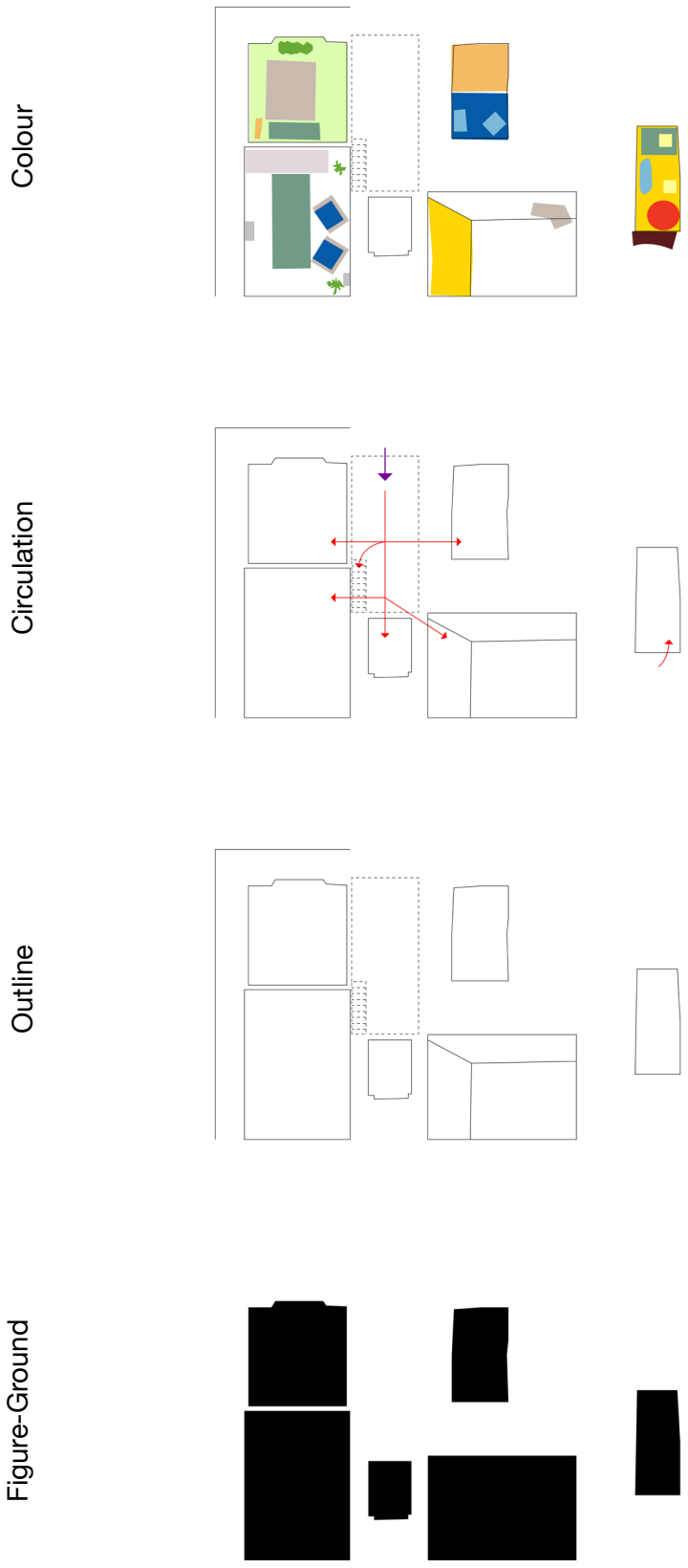


Figure 9.5 - Graphic analysis of Late/Non-Adopters' smart home.

Appendix E. Qualitative Datasets

Section 1. Open Repository Links

The qualitative datasets relative to each research phase can be found in the following open repository links:

- Phase 1: https://doi.org/10.5281/zenodo.10912781
- Phase 2: https://doi.org/10.5281/zenodo.10913030
- Phase 3: https://doi.org/10.5281/zenodo.10913103
- Phase 4: https://doi.org/10.5281/zenodo.10913113

Section 2. Qualitative Datasets Sample

Qualitative datasets organised by this research are composed of participant-generated visual data and audio transcriptions. The audio recording transcriptions follow the model presented in Appendix D, Section 1. This type of data integrates the hour phases' datasets (open links above). Regarding participant-generated visual data, it is only available for Phase 1 and 2. The type of visual data can be seen bellow:

(i). Sample from Phase 1-A

P1_WSP-PRO-VIS_007.jpg

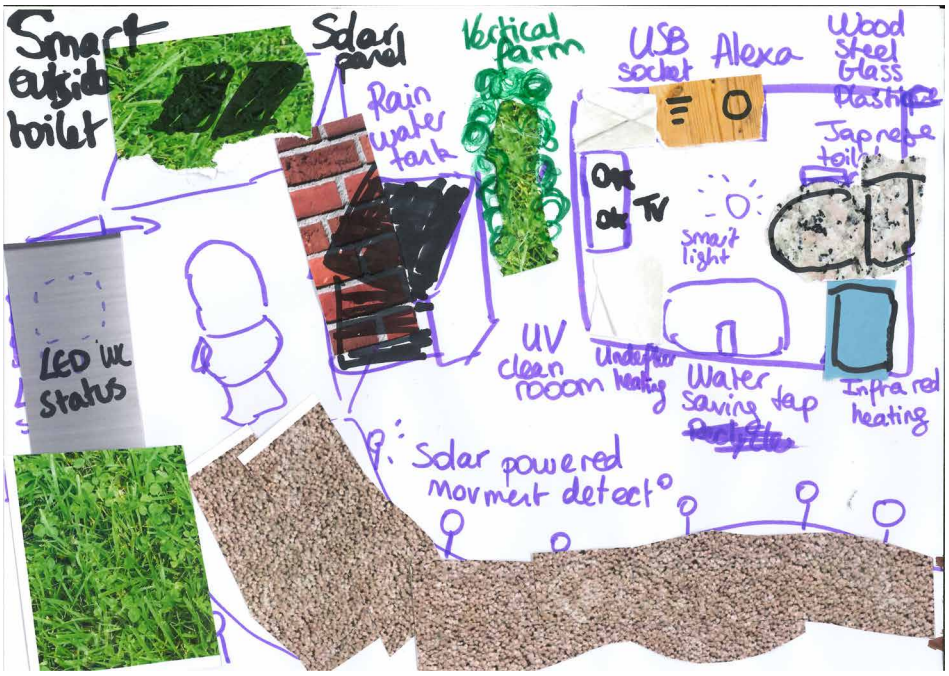


Figure 9.6 - Sample of qualitative visual data generated by participants in Phase 1.

(ii). Sample from Phase 1-B

P1_WSP-EA-VIS_006.jpg

Figure 9.7 - Sample of qualitative visual data generated in the second activity of Phase 1.

(iii). Sample from Phase 2-A

P2_WSP-PA-G4-VIS_000.jpg

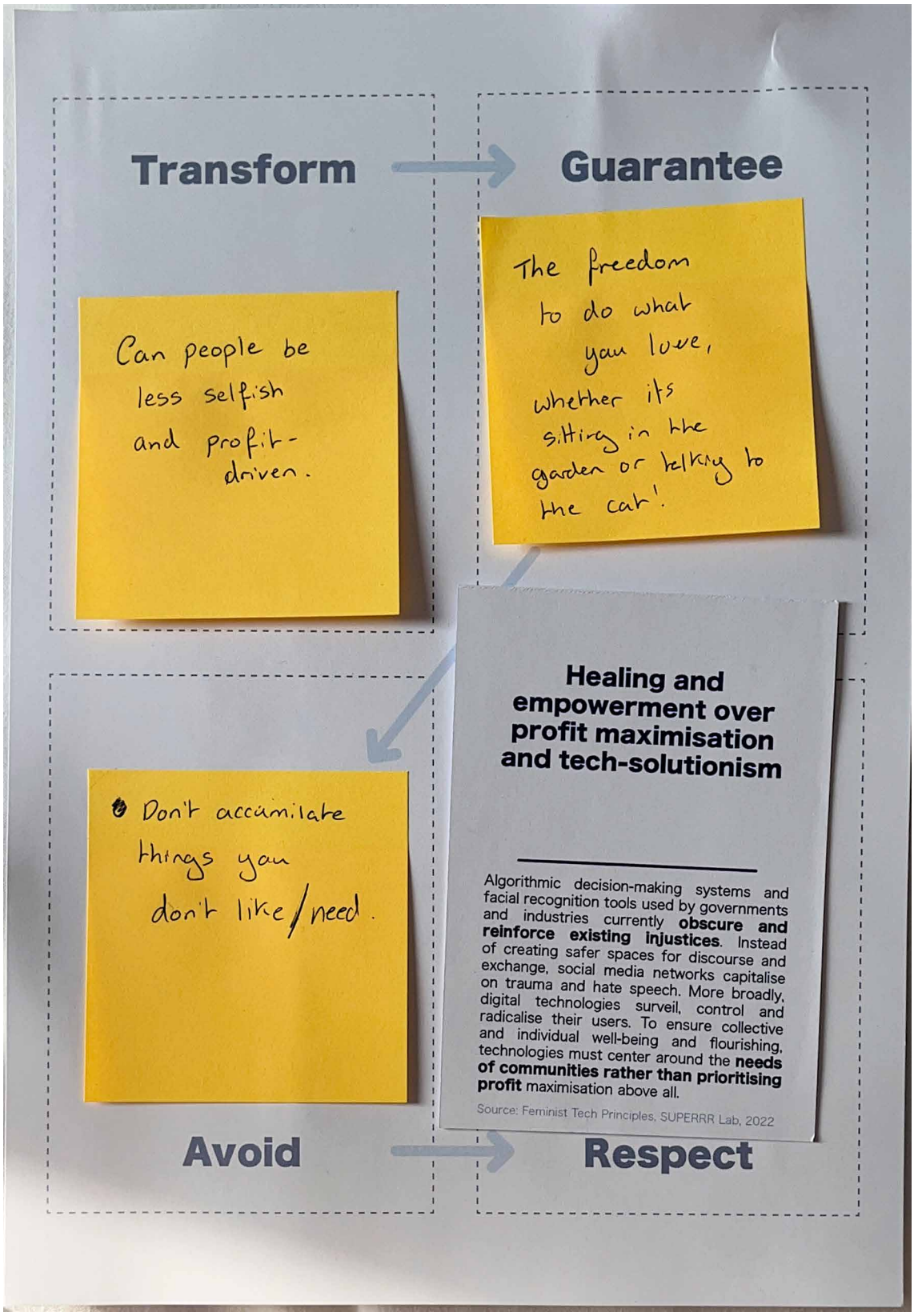


Figure 9.8 - Sample of qualitative data generated in Phase 2.

(iv). Sample from Phase 2-B

P2_WSP-PA-G4-VIS_003.jpg

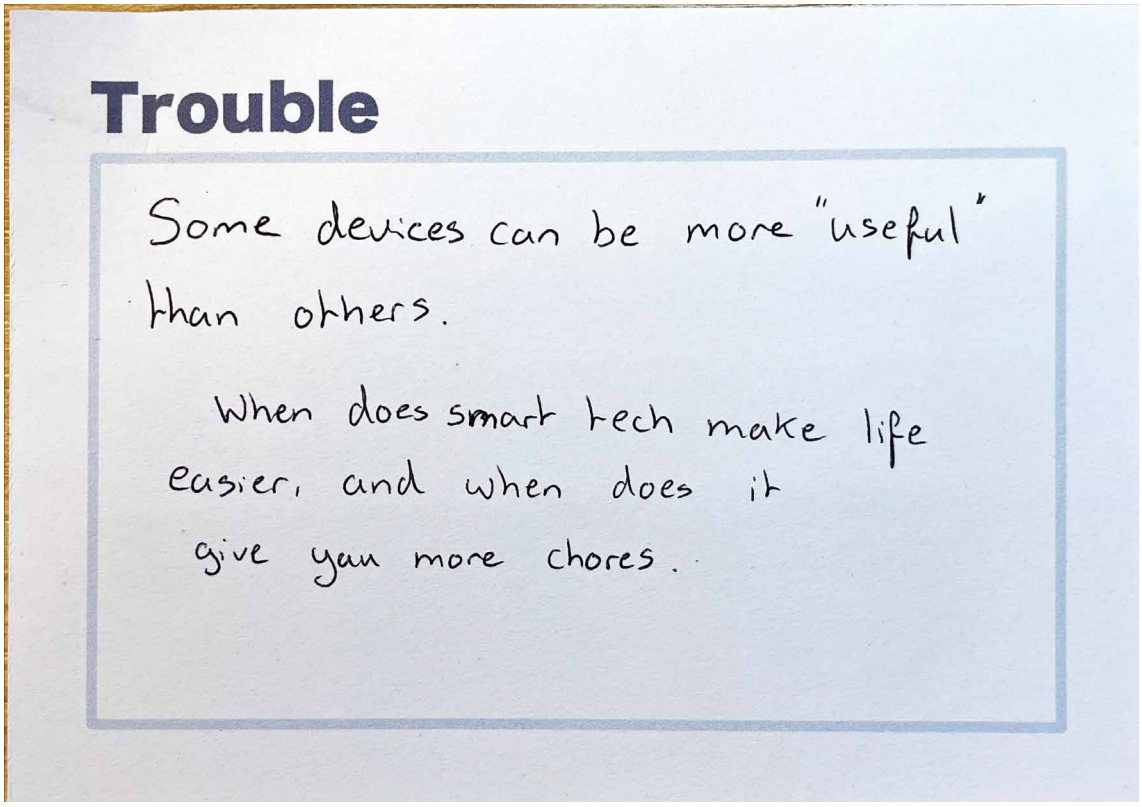


Figure 9.9 - Sample of qualitative data generated in Phase 2 regarding trouble framing.