# Exploring Pleasure-Driven Design Through Internet of Things (IoT) Transformations

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# Author’s declaration

This thesis represents partial submission for the degree of Doctor of Philosophy at the Royal College of Art. I confirm that the work presented here is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

During the period of registered study in which this thesis was prepared the author has not been registered for any other academic award or qualification. The material included in this thesis has not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

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# Abstract

The Internet of Things (IoT) has transformed numerous analogue products into IoT products with embedded sensors, advanced features and novel experiences. As these connected objects become ubiquitous, designers have shifted from a tool-oriented to an experience-oriented approach. However, the focus on maximising living efficiency and profit growth has often obscured the importance of pleasurability and experimentation in designing IoT products. Recognising the historical and psychological significance of pleasure in human experiences, this thesis proposes "pleasure-driven design" as an overarching concept for designing interactive product experiences that prioritise pleasure. While several general pleasure-driven design methods exist, they have not adequately addressed the distinctions between analogue and IoT products in terms of pleasurability, leaving a gap that this practice-based design research seeks to fill. Additionally, concerns over privacy and automated decision-making in IoT objects pose challenges to designing pleasurable experiences. Therefore, this work explores new possibilities for pleasure-driven design by leveraging the transformation of analogue products into IoT products.

This work adopts an emergent methodology that integrates a research-through-design approach with a mixed methods approach, employing multiple methods including questionnaires, workshops, material speculation, co-speculation, technology probes and interviews. It begins with a literature review outlining the importance of pleasurable experiences in IoT transformations, analysing the role of pleasure in experience design and assessing existing pleasure-driven frameworks and IoT creativity-supporting tools. The exploratory practices identify differences between an IoT product and its analogue form in terms of pleasurable experiences and uncover deficiencies in current frameworks. Subsequently, *the Internet of Things Transformations for Pleasurable Experiences (IoTT for PLEX) Framework* is developed

to support designers in delivering pleasurable experiences by utilising IoT transformations as materials and to enable design researchers to explore pleasure-driven design in this context. The framework is initially tested with designers and then with human-computer interaction (HCI) researchers through material speculation. Based on the new framework, *the CloudPlanter* – a technology probe and research product – is developed by the author and applied in a co-speculation experiment involving four pairs of participants to explore the future relationship between humans and networked objects.

This thesis makes a valuable contribution to both the design and HCI research communities by expanding upon existing pleasure-driven experience design approaches specifically for IoT products and uncovering the mutual influence between pleasure-driven design and IoT transformations. The major contribution of this PhD project is the development of the novel *IoTT for PLEX Framework*, proposed as a new design and research method for exploring pleasure-driven design through IoT transformations. The research also generates knowledge at an intermediate level, including reflections on applying established approaches and an emergent methodology of investigating pleasure-driven design within the specific contexts and cases of IoT transformations. The thesis, presented as an annotated portfolio, embodies and enacts design theories. It offers new possibilities that should help designers create novel experiences through IoT transformations, inspire future research in IoT experience design and empower the IoT product industry to create more pleasurable and meaningful products.

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# 1. Introduction

## 1.1 Research Motivations

While pursuing my bachelor's degree in Product Design at the University of Lincoln, I developed a keen interest in Internet of Things (IoT) smart products. During this period, I trained to become a product designer focused on creating commercial products that meet market demands and consumer needs. I designed a pair of IoT chopsticks named "Nutristicks" (see Figure 1.1) in my final bachelor's project. *Nutristicks* are equipped with a spectrometer to detect nutritional elements in food and record the user's nutritional intake on the cloud. Users could access their data and track intake and nutritional balance via the *Nutristicks* application on their mobile phones. This project marked my first attempt at IoT product design, where I encountered the sophistication and complexities of designing interactions between multiple connected devices and their users. I realised the importance of considering the entire network not just the individual product when designing for IoT products. This experience allowed me to appreciate the vast potential of IoT products for innovative design, as opposed to the analogue products such as furniture, Christmas decorations and novelty souvenirs that I had previously worked on.


**Figure 1.1 Renders of *Nutristicks (2017).***

The motivation for this thesis stemmed from my interdisciplinary master's degree in Design Informatics at the University of Edinburgh. Established within the Institute for Design Informatics, this unique programme accepts students from design and computer science backgrounds. Collaborating with computer scientists during this time enriched my research interests in IoT and the intersection of design and HCI. Working in a research-oriented environment honed my skills in speculative and experimental research methods, which were invaluable in conducting IoT-related design research projects. My master's dissertation explored the "health" of IoT smart products from an object-oriented perspective, producing IoT artefacts that communicated on behalf of other products in the same IoT network through counterfactual interactions. The interactive installation presenting the counterfactual interactions in this system is shown in Figure 1.2. This project enabled me to reflect on my dual identity as a designer and a researcher, which consolidated my interest in becoming a design and HCI researcher. My enriching experience during my master's study acted as a catalyst and inspired me to explore the experience design of IoT products further. Throughout the research journey of this thesis, I shifted my roles between design researcher, experience designer and HCI researcher. Playing multiple roles allowed me to contribute to the development of new design knowledge, an innovative methodology, novel design methods and a deeper understanding of human-computer relationships.

**Figure 1.2 Installation of my design concept showcased at my master's degree exhibition: a toaster, a microwave and a lamp in an IoT system designed to monitor each other's "health" (The University of Edinburgh, 2019)**.

## 1.2 Context

The development of ubiquitous computing has transformed numerous analogue products into IoT forms. Various domestic electronic products embedded with sensors have been connected to the internet, offering advanced features and novel experiences. Unlike analogue products, IoT products possess enhanced functionalities and a higher level of agency, which signifies their capacity to autonomously make decisions or execute actions during multiple interactions. This transformation has intertwined material and immaterial elements and facilitated people's engagement with digital data through IoT products, forming a more complex human-object relationship than with analogue products. Therefore, the experience design for connected products presents complexities significantly different from those of traditional analogue products. Users' experiences within an IoT system can be distributed across multiple products, each with varying capabilities, form factors and purposes. Moreover, the sensemaking of data surrounding an IoT product is as critical as the product itself in influencing the human experience. The third wave of HCI expanded the understanding of user experiences from pragmatic and cultural-historical to emotional and aesthetic aspects. In response to these networked objects, designers have shifted from a product-oriented to an experience-oriented approach.

However, despite their enhanced capabilities, these transformed IoT products do not always guarantee pleasurable experiences. Some IoT products transformed from analogue products are not meaningful or enjoyable, which has resulted in their abandonment and slow adoption. The concealed nature of data in IoT systems may evoke negative emotional responses, such as concerns over privacy and security. Many designers' efforts in the experience design of IoT products have been made to maximise living efficiency and profit growth that obscured pleasurability. IoT products developed in recent years have lost the novelty and experimental elements compared to when they first emerged. Importantly, pleasure is an experience universally pursued throughout human history. Pleasurability is a crucial aspect of product experiences in their design, contributing alongside brand loyalty, task effectiveness and safety to the financial success of product brands. While general pleasure-driven design methods have been developed, they lack adaptation to the specific IoT context; this gap needs further exploration.

## 1.3 Research Questions

This thesis, therefore, investigates how "pleasure-driven design" can be influenced by "IoT transformations" through practice-based design research. It aims to reveal the relationship between pleasure-driven design and IoT transformations, develop new methods for designers and provide insights into design and HCI research. The target audience for this thesis includes experience designers, product designers and interaction designers focusing on new experiences for IoT products, as well as design and HCI researchers whose research interests relate to IoT and experience design.

The thesis addresses the main research question:

> What new possibilities for pleasure-driven experience design are suggested by the transformations from analogue products into IoT products?

Three sub-questions are also addressed:

1. What are the differences between the pleasurable experiences of an IoT product and the analogue product from which it was transformed?
2. Which methods can support the creation of novel experiences through IoT transformations based on existing pleasure-driven design theories?
3. How do pleasure-driven experience design and the transformations from analogue to IoT products influence future relationships between human beings and networked objects?

The thesis will begin with an exploration of these research questions through a literature review to understand the state of the art and position this research within the existing literature.

# 2. Literature Review

## 2.1 IoT Transformations

This literature review starts with an exploration of design and HCI literature on IoT products with a specific focus on IoT transformations and highlights the importance of designing pleasurable experiences within these transformations.

### 2.1.1 Understanding IoT Transformations

It has been over 20 years since Kevin Ashton coined the term "Internet of Things" in 1999 (Ashton, 2009). The transformation from analogue to IoT products has become ubiquitous, with people now owning a wide range of IoT devices in their homes. Despite the significant presence of 14 billion IoT devices worldwide, this number is predicted to nearly double, reaching 25.434 billion by 2030 (Jay, 2020). Since 2020, IoT-connected devices (e.g., connected cars, smart home devices, connected industrial equipment) have outnumbered non-IoT-connected devices (smartphones, laptops and computers), and this trend is set to continue, with an estimated 75% of all devices expected to be IoT-enabled by 2030 (IoT Analytics, 2020). Interestingly, in this statistical analysis, only specialised embedded devices and connected sensors, as categorised by Rowland et al. (2015) (to be discussed in *Section 2.1.3*), were counted as IoT products, excluding smartphones, laptops and computers. This differs from the definition of IoT products that will be introduced in *Section 2.1.2*. If the definition from this thesis were applied, the number of IoT devices could be even higher. When these services and products are operational, they generate a large amount of live data and form a complex, dynamic network (Speed & Luger, 2019).

Atzori et al. (2010) explored the transformation from analogue to IoT systems from a technical perspective, illustrating the convergence of three main visions in IoT:

Things-oriented, Internet-oriented and Semantic-oriented visions (see Figure 2.1). Utilising this paradigm, they identified and categorised the principal concepts, technologies and standards in the IoT field. In the "Things"-oriented vision, wireless technologies, including RFID, Unique/Universal/Ubiquitous Identifier (uID), Near Field Communications (NFC), Wireless Sensors, Sensing Platforms (WISP) and Actuator Networks (WSAN), are employed to give objects unique identifications and enable connections among them. Atzori et al. introduced Sterling's (2005) notion of "spime" to describe these interconnected objects within an IoT system. Sterling described six developmental statuses of objects: artefacts, machines, products, gizmos, spimes and biots. Currently, IoT products closely resemble spimes; these programmable products are connected to networks that generate substantial data within an immaterial system. Spimes can update themselves in their users' database and inform users of required service calls with appropriate links to service centres (2005:p.77). In a spime-driven technosociety, every stakeholder in the network can negotiate, a process Sterling terms "wrangling". The exchange of information between products, IoT product developers and users resembles these negotiations among "Wranglers". He advocated for spime designers to "revolutionise the interplay of humans and objects" (2005:p.132) , calling for more attention and deeper analysis of objects than previously given. Sterling's concept of spime emphasised that "things" in IoT combined physical objects and intangible data and assigned to designers the critical task of building connections between the material and the immaterial. He predicted that spimes would dominate the industry by 2030, driving advancements in data technology and augmenting existing products. Speed (2011) argued that spimes can be disassembled and recycled into the manufacturing stream; however, the data they generate, such as memories, can be retained and benefit interested parties. In contrast, the lifecycle of current IoT products is mostly linear, ending with the end users and often resulting in data loss.

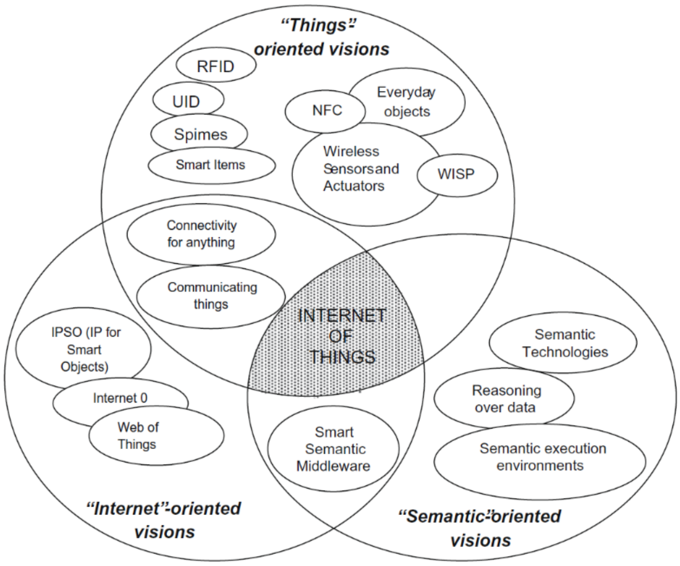


**Figure 2.1 Atzori et al.'s (2010) "Internet of Things" paradigm.**

In the "Internet"-oriented vision, the Internet Protocol for Smart Objects (IPSO) (Vasseur & Dunkels, 2010) is utilised to connect smart objects globally. Internet 0 (Gershenfeld, Krikorian & Cohen, 2004), a computer networking layer, enables routing "IP over anything", thereby integrating smart objects into a "Web of Things" (Guinard & Trifa, 2009) using web standards. The intersection of "Things"-oriented and "Internet"-oriented visions focuses on building connectivity and communication among these objects. The "Semantic"-oriented vision speculates a future where a vast number of objects are connected in a Future Network. Semantic technologies (Toma, Simperl & Hench, 2009), which facilitate machine understanding of data, are expected to play a significant role in this envisioned future. IoT products equipped with semantic technologies are expected to reason over data and create semantic execution environments. Although Atzori's framework was developed from a technical perspective, the principal concepts and key technology terms within the framework provide essential knowledge of IoT transformations, which lay the groundwork for this thesis before initiating further explorations.

### 2.1.2 Defining "IoT Products"

In this thesis, the term "IoT product" is used to describe smart products that possess the capabilities to collect data from their environment, connect to networks via the internet and transfer data. This is in contrast to "analogue products", which are unconnected and isolated from each other, even though some may be digital. In HCI and design research, various terms have been employed to describe the products interconnected within an IoT system (e.g., connected devices (Apthorpe et al., 2019; Gorkovenko et al., 2020; Lindley, Coulton & Cooper, 2017), IoT devices (Arabi et al., 2022; Vaniea, Tallyn & Speed, 2017; Worthy, Matthews & Viller, 2016), connected products (Rowland et al., 2015) and smart products (Desjardins & Wakkary, 2016; Kitazaki, Nicenboim & Giaccardi, 2019; Strengers et al., 2019)). The term "IoT products" has been selected for use in this thesis because it effectively conveys the dual emphasis on connectedness and smartness inherent in the physical objects within an IoT network. Consequently, it encompasses the meanings of "IoT devices", "connected devices", "smart products" and "connected products".

### 2.1.3 Categorisation of IoT Products

The categorisation of IoT products would help design and HCI researchers to group products with similar attributes, better understand their features and reveal design opportunities in IoT transformations. This section introduces two different methods for classifying IoT products that particularly reflect the transformations from analogue products to IoT products, the first from Rowland et al. (2015) and the second from Cila et al. (2017).

Rowland et al. (2015) categorised IoT products by their functionality, separating them into four types: multipurpose computers, specialised embedded devices, connected sensors and passively trackable objects. Multipurpose computers are "powerful computers designed to perform a variety of computing tasks" (ibid., p.31). Specialised embedded devices are objects "specialised to perform particular tasks" with "onboard computation and connectivity" (ibid., p.32). Connected sensors are "small embedded devices used for capturing data from the physical world, and passing this to a networked service" (ibid., p.33). Passively trackable objects are unconnected objects with "a unique identity that is associated with information about them online" (ibid., p.43). A comparison of four types of IoT products can be found in Table 2.1. This categorisation highlights the differences in smartness and capability when various analogue products are transformed into their IoT forms.

**Table 2.1 Types of IoT products based on Rowland et al. (2015).**

| ***Type*** | **Multipurpose Computer** | **Specialized Embedded Device** | **Connected Sensor** | **Passively Trackable Object** |
|---|---|---|---|---|
| ***User Interaction*** | Rich onboard interaction capabilities (e.g., through screens and keyboards) | May have limited input/outputs; advanced interactions handled via web/mobile apps | Via web/ mobile apps | Via web/ mobile apps |
| ***Functionality*** | Generalized; can run a wide range of applications | Specialized for specific functions | Single task | Identity only |
| ***Processing*** | Powerful onboard processor | Onboard processor, with some functions provided by cloud service | Mostly in cloud service | In cloud service |
| ***Examples*** | PCs, smartphones, tablets, smart TVs, set-top boxes and game consoles | Thermostats, bathroom scales, connected door locks, connected light switches | Weather station sensors, body index sensors | RFID tags, transport cards, NFC devices, QR codes |

Cila et al. (2017) proposed a products-as-agents taxonomy separating IoT products into three roles based on the behaviours they exhibit as agents: the Collector, the Actor and the Creator. The Collectors "sense and process information"; specifically, they "aggregate data from embedded sensors or social media platforms and feed the data back to its user, to other users, or to other products" (ibid., p.451). The Actors not only "sense and interpret data like the Collector products", but also "act autonomously according to the behaviours of users or other products" (ibid., p.452). The Creator is "drawn from near future scenarios" (ibid., p.453). They represent a potential form of network objects, "making a tangible difference on their form, the environment they are in, and the way they are used" (ibid., p.454). A comparison of the three roles of IoT products is shown in Table 2.2.

**Table 2.2 Roles of IoT products based on Cila et al. (2017).**

| ***Role*** | **the Collector** | **the Actor** | **the Creator** |
|---|---|---|---|
| ***Also Known as*** | the data reader | the interventionist | the self-aware |
| ***Used for*** | understanding, making invisible patterns visible | creating dialogues | creating futures |
| ***The Degree of Product Agency*** | Low | Medium | High |
| ***Examples*** | Lapka personal environment monitor | Addicted Toaster (Rebaudengo, 2012), Hello Lamppost (Esses, 2024) | Starfish robot (Bongard, Zykov & Lipson, 2006), 3D print robot system (Samuelsen & Glette, 2015) |

Combining these two classification methods, multipurpose computers align with the role of the Actor, while specialised embedded devices and connected sensors correspond to the Collector, but there is no Creator counterpart in the categorisation by Rowland et al. (2015). Similarly, in the taxonomy from Cila et al. (2017), no role has been defined for passively trackable objects. When designers transform analogue products into IoT forms, they need to identify and understand the different types of IoT products, their degree of agency and the roles they can play. This understanding will enable them to clarify their design objectives and ensure that new IoT products facilitate appropriate and meaningful interactions. The two taxonomies provide a useful framework for this purpose.

### 2.1.4 Why Designing Pleasurable Experiences for IoT Is Important

When human factors were introduced to IoT, experience design became more important in this technology-driven field. Koreshoff et al. (2013) and Soro et al. (2017) adapted Atzori et al.'s (2010) IoT framework (introduced in *Section 2.1.1*) to incorporate human factors. Koreshoff et al.'s framework (2013) (see Figure 2.2) emphasised the importance of considering IoT in relation to HCI research. In the "Things" category, they observed that HCI literature places less emphasis on specific components and more on integrating computing into everyday objects, exploring the new possibilities this integration offers. However, Koreshoff et al. claimed that the "Internet" category is not a primary focus of HCI. In the "Semantic" category, the HCI community concentrates on analysing and presenting data collected by networked objects, acknowledging the challenge of clearly representing complex information without human intervention. The "Internet/Things" category shifts the focus to the impact of connectivity on designing IoT objects. The "Semantic/Internet" category reveals an increased interest in the HCI field in the interactions between "things" in a network, rather than the technical aspects of making these connections. In the "Things/Semantic" category, HCI research is centred on how IoT data can be made sense of by humans and how objects can respond to the data they collect. Koreshoff et al.'s work indicates that HCI research primarily focuses on "things", followed by "semantics" and then the intersection of these two categories, suggesting that "things" serve as a starting point for IoT. Koreshoff et al.'s framework highlights the human factors of IoT in HCI and suggests a shift from a technology-centred perspective to a human-centred perspective.

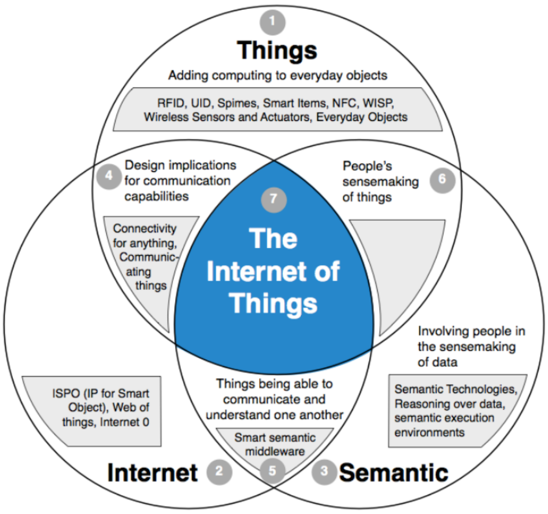


**Figure 2.2 Koreshoff et al.'s (2013) Internet of Things framework.**

In Soro et al.'s (2017) framework, the category of "semantic" is replaced by "people" (see Figure 2.3). Although objects are capable of communicating and reasoning with one another, Soro et al. pointed out that humans will always be required to give meaning to objects and the representations of data. Consequently, the "semantic" category is integrated into the "thing" category, and "people" occupy the third set in the framework. The revised framework further addressed the human factors within an IoT system, emphasising that humans use IoT products, and that the human-machine interface must be considered in the design process. Values and emotions appear in the "people" category, highlighting the emergence of pleasurable experiences as a consideration in human-centred IoT design. This thesis prioritises the influence of IoT transformations on human-centred experience design. While Artificial Intelligence (AI) is a significant research area within the IoT, it is not the core focus here. Although AI technologies in certain IoT devices may influence pleasurability, this aspect was not singled out as a primary research interest at this stage. Therefore, literature related to AI is not specifically analysed in this thesis.

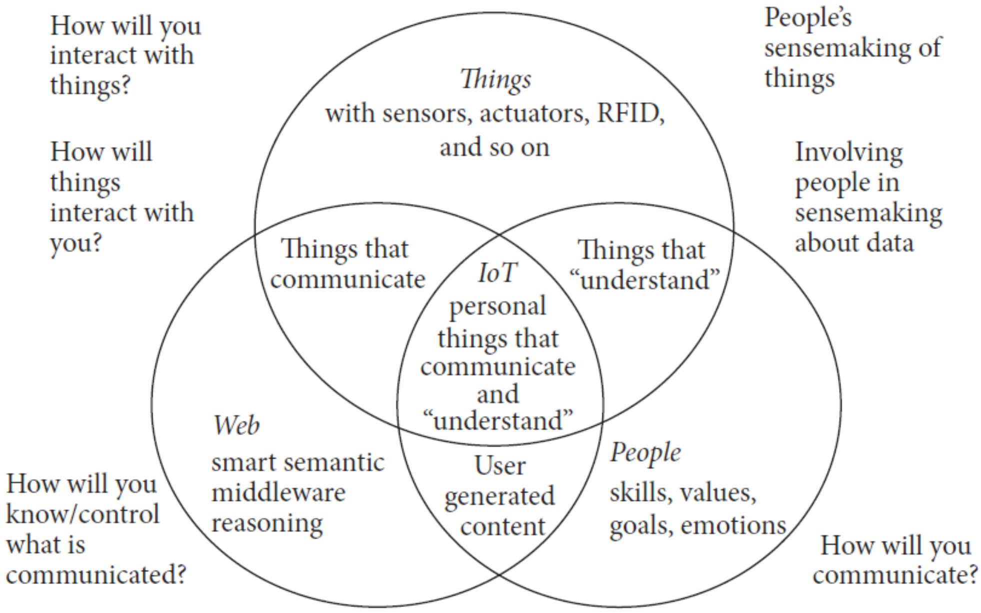


**Figure 2.3 Soro's (2017) modified framework based on Atzori et al.'s (2010).**

In human-centred design (HCD), Norman (2005a) advocated that all designed elements should positively contribute to the activity that is being performed. Pleasurability was listed by him as one of three HCD axioms for designing Information Appliances (the other two were simplicity and versatility):

> Pleasurability - products should be pleasurable, fun, enjoyable. A joy to use, a joy to own. (Norman, 1999:p.67)

Miller (2016) also argued that joy and pleasure are crucial components of positive digital system experiences. In the context of the IoT, which generates a vast array of data, Norman's axioms and Miller's view remain highly relevant. The pleasurability of IoT products is not only shaped by their performance in completing tasks but also by the data exchanged and interactions hidden in the cloud. When an analogue product is transformed into an IoT product, users' memories can be stored as associated social data, which can be saved and transferred even if the physical object does not remain (Speed, 2011:p.21). Moreover, Strengers et al.'s study (2019) revealed that

IoT products, which constitute a smart environment, can shape ambient aesthetics and enable users to interact with the technology in various ways, thereby delivering pleasure. Hassenzahl and Tractinsky argued that "one of HCI's main objectives in the future is to contribute to our quality of life by designing for pleasure rather than for absence of pain (2006:p.95)."

While IoT transformations offer opportunities for designing for pleasure, they also bring challenges. Market research showed that the high price of IoT products compared to analogue ones slowed consumer adoption (Titcomb, 2016). In their analysis of IoT manifestos, Fritsch, Shklovski and Douglas-Jones (2018) observed that developers expressed frustration and uncertainty because they struggled to narrate the new possibility offered by IoT, and these manifestos conveyed a profound worry and even fear about the state of the world and the impact of technology. De Roeck and Smit (2020) suggested that compared to the emergent phase of IoT products, those developed in 2020 prioritised optimised solutions for efficient living all the time, resulting in a loss of playfulness and experimentation—the essence of ludic design (Gaver et al., 2004). They argued that IoT product design should focus on people's identity and agency as humans rather than catering to profit growth. Additionally, concerns about privacy and opaque data practices diminished the positive user experience of IoT products (Lindley, Coulton & Cooper, 2017). Coskun, Kaner and Bostan (2018:p.15) noted that the automation of domestic IoT products could negatively impact users' social roles and pleasurable activities at home. Aldossari and Sidorova (2020) found that performance expectancy, effort expectancy, social influence, hedonic motivation and price value influence consumer acceptance of IoT smart home products, while trust and security risk play a significant role.

However, studies have indicated that perceived enjoyment enhances technology acceptance (Davis, Bagozzi & Warshaw, 1992; Igbaria, Schiffman & Wieckowski, 1994; Zhang & Li, 2004), and products that evoke positive emotions are more likely to be favoured (Norman, 2005b; O'Brien & Toms, 2008). Hedonic qualities in interactive products also increase the perceived value (Hassenzahl et al., 2000; Diefenbach, Kolb & Hassenzahl, 2014). With growing environmental concerns and the need to reduce e-waste, sustainable experiences that extend the lifespan and ease of repair of IoT products are advocated (Pilling et al., 2023; Lechelt, Gorkovenko & Speed, 2024). Positive experiences can prolong product use by increasing momentary pleasure and improving long-term well-being (Desmet & Pohlmeyer, 2013). From a human-centred perspective, designing IoT products to deliver pleasurable experiences can facilitate user acceptance, enhance emotional value and foster sustained usage. Thus, exploring how designers can create pleasurable experiences through IoT transformation is essential for identifying new design opportunities and addressing the challenges encountered.

## 2.2 From Experience Design to Pleasure-Driven Design

The previous section highlighted the need to improve the pleasurability of IoT products. To explore designing pleasurable experiences through IoT transformations, understanding the notions of experience and experience design is useful. In the fields of design and HCI, there is some ambiguity surrounding the terms "experience", "user experience (UX)", "UX design" and "experience design". This section aims to clarify these terms and explain why "experience design" has been chosen as the preferred term for this thesis.

### 2.2.1 Experience and User Experience (UX)

The notion of experience in pragmatism brought into design and HCI fields originated from American philosopher and psychologist John Dewey (1934), who discussed art as experience. Dewey distinguished experience in general from "an experience". Experience in general is the continuous interaction between a living entity and its surrounding environment, integral to the process of life itself that can often be fragmented or incomplete due to distractions, disconnections or inner lethargy (Dewey, 1934:p.35). However, it qualifies as "an experience" since its beginning and end serve to form a cohesive whole and it processes its individualising quality and self-sufficiency (ibid., p.35). Dewey argued that conscious experience can be understood as the perceived relationship between action (doing) and response (undergoing). This relationship includes how art as a form of production sustains a connection with perception and appreciation that fosters enjoyment (ibid., p.47). He noted that an object could produce enjoyment in aesthetic perception when the factor determining an experience is above the threshold of perceptions and can manifest itself. McCarthy and Wright (2004) introduced Dewey's concept of aesthetic experience to HCI and design communities. They argued that when viewing technology as an experience, it transcends the mere focus on mechanics of digital systems and should also encompass sensory, emotional, cultural and social effects (McCarthy & Wright, 2004:pp.190–193).

The terms "experience" and "user experience (UX)" are widely employed and sometimes interchangeable in both design and HCI research, but for this thesis, distinctions are necessary to ensure consistent use of the proper term. Table 2.3 compares twelve definitions of experience, product experience and UX from the literature, evaluating whether they incorporate emotional aspects, orient towards a product and differentiate experience from UX. This analysis aims to select a proper term for the scope of this thesis. Notably, definitions 5, 6, 7 and 8 from Hassenzahl (2008, 2010) specifically differentiate between experience and UX, positioning UX as a narrower discipline focused exclusively on outcomes derived from interactive products. Definitions 2, 3, 6, 8-12 collectively convey the idea that UX encompasses multiple facets of how users interact with a system, product or service. The quality of the UX can be influenced by various factors, including the inherent properties of the system, product or service, the characteristics and the cultural background of the user and the specific social context in which the interaction takes place. As Ritter, Baxter and Churchill (2014) have noted, "UX" is occasionally used interchangeably with "usability", though these two terms differ in their primary focus. Usability and usability engineering primarily focus on the efficiency and effectiveness of task performance, whereas UX and experience design explore the realm of users' emotions, feelings, values and their immediate and delayed responses. This shift may be attributed to the fact that historically HCI had a narrow focus on the design and usability of computing systems, but nowadays HCI has greatly expanded in its scope (Churchill, Bowser & Preece, 2013).

While "UX" typically relates to direct interactions between a user and a product, "experience" encompasses affective responses not limited to direct product interactions but also includes mediated experiences. In definition 4, Desmet and Hekkert (2007) emphasised the central role of affect in the processes that generate experience, noting that product interactions can transform users' core affects in various ways, such as through subjective feelings, behavioural reactions, expressive responses and physiological reactions. In definitions 5 and 7, Hassenzahl (2010) described experiences as complex constructs that bridge the realms of culture and psychology, suggesting that methodologies rooted in psychological perspectives are crucial for designing and understanding these multifaceted experiences. In the context of IoT which includes object-to-object, object-to-human and human-to-human interactions within a network (International Telecommunications Union, 2016), some experiences are not elicited during the direct interactions between users and products. This thesis discusses the broader category of "pleasurable experiences", which are influenced by but not limited to direct interactions with IoT products. It emphasises these experiences as extending beyond mere usability to include deeper emotional and psychological connections. Therefore, the term "pleasurable experiences” was preferred over “pleasurable UXs” to capture the wider scope of actor engagement and psychological aspects.

**Table 2.3. Definitions of Experience and User Experience (sorted by year of publication).**

| ***No.*** | **Chosen Term** | **Definition** | **Incorporating emotional aspects** | **Product-oriented** | **Distinguishing experience and UX** |
|---|---|---|---|---|---|
| ***1.*** | Experience | “experience of technology involves something larger than usability or one of its dimensions such as satisfaction or attitude” (McCarthy & Wright, 2004:p.6) | YES | YES | NO |
| ***2.*** | User Experience | “UX is a consequence of a user’s internal state (predispositions, expectations, needs, motivation, mood, etc.), the characteristics of the designed system (e.g. complexity, purpose, usability, functionality, etc.) and the context (or the environment) within which the interaction occurs (e.g. organisational/social setting, meaningfulness of the activity, voluntariness of use, etc.)”(Hassenzahl & Tractinsky, 2006, 95). | YES | YES | NO |
| ***3.*** | User Experience | “(UX is) the entire set of affects that is elicited by the interaction between a user and a product, including the degree to which all our senses are gratified (aesthetic experience), the meanings we attach to the product (experience of meaning) and the feelings and emotions that are elicited (emotional experience)” (Hekkert, 2006, 160). | YES | YES | NO |

| ***No.*** | **Chosen Term** | **Definition** | **Incorporating emotional aspects** | **Product-oriented** | **Distinguishing experience and UX** |
|---|---|---|---|---|---|
| ***4.*** | Product Experience | "We use 'product experience' to refer to an experience that is affective. In psychology, the term affect, or affective state, is generally used to refer to all types of subjective experiences that are valenced, that is, experiences that involve a perceived goodness or badness, pleasantness or unpleasantness. Core affect theory offers a simple, yet powerful, way to organize product experience, because all possible experiences involved in the user-product interaction can be described in terms of core affect. We define product experience as a change in core affect that is attributed to human-product interaction" (Desmet & Hekkert, 2007:pp.2–3). | YES | YES | NO |
| ***5.*** | Experience | "Experience itself is an ongoing reflection on events, we go through or as Forlizzi and Battarbee put it: a constant stream of self-talk." (Hassenzahl, 2008:p.11) | YES | NO | YES |
| ***6.*** | User Experience | "I define UX as a momentary, primarily evaluative feeling (good-bad) while interacting with a product or service." (Hassenzahl, 2008:p.12) | YES | YES | YES |
| ***7.*** | Experience | "An experience is a story, emerging from the dialogue of a person with her or his world through action." (Hassenzahl, 2010:p.8) "Experience emerges from the intertwined works of perception, action, motivation, emotion and cognition in dialogue with the world (place, time, people and objects)." (Hassenzahl, 2010:p.16). | YES | NO | YES |

| ***No.*** | **Chosen Term** | **Definition** | **Incorporating emotional aspects** | **Product-oriented** | **Distinguishing experience and UX** |
|---|---|---|---|---|---|
| ***8.*** | User Experience | "User experience is not much different from experience per se. It simply focuses our interest on interactive products (as opposed to, for example, other people) as creators, facilitators and mediators of experience." (Hassenzahl, 2010:p.8). | YES | YES | YES |
| **9.** | User Experience | "The overall appraisal, judgment or evaluation of the subjective and conscious encounter that the user has with an artefact through interaction, occurring in a particular context and time." (Ortiz, Juan & Aurisicchio, 2011:p.3). | YES | YES | NO |
| **10.** | User Experience | "We believe the user experience includes three main defining characteristics:<br>• A user is involved<br>• That user is interacting with a product, system, or really anything with an interface<br>• The users' experience is of interest, and observable or measurable." (Tullis & Albert, 2013:p.14) | YES | YES | NO |

| ***No.*** | **Chosen Term** | **Definition** | **Incorporating emotional aspects** | **Product-oriented** | **Distinguishing experience and UX** |
|---|---|---|---|---|---|
| **11.** | User Experience | "User's perceptions and responses that result from the use and/or anticipated use of a system, product or service.<br>Note 1 to entry: Users' perceptions and responses include the users' emotions, beliefs, preferences, perceptions, comfort, behaviours, and accomplishments that occur before, during and after use.<br>Note 2 to entry: User experience is a consequence of brand image, presentation, functionality, system performance, interactive behaviour and assistive capabilities of a system, product or service. It also results from the user's internal and physical state resulting from prior experiences, attitudes, skills, abilities and personality; and from the context of use." (International Organization for Standardization, 2019). | YES | YES | NO |
| **12.** | User Experience | "User experience includes all the aspects of the interaction between the end-user with the company, its services and its products." (Nielsen Norman Group, 2023). | YES | YES | NO |

### 2.2.2 Experience Design

In the fields of design and HCI, the distinction between "UX design" and "experience design" also often remains frequently blurred, leading to their interchangeable use. "UX design" is a term prevalent in both design and HCI research (Hassenzahl, 2008; Hassenzahl & Tractinsky, 2006; Kuniavsky, 2010; Schankin et al., 2022), as well as the design industry (Warren, 2017; Nielsen Norman Group, 2023). It denotes a product-oriented approach, encompassing the comprehensive user experiences throughout the entire process of interacting with a digital or physical product, including the integration of detailed experiences (Interaction Design Foundation, 2024). On the other hand, "experience design" primarily resides within the academic discourse of design. It is employed to describe a specific type of experience-oriented design research dedicated to creating experiences that produce tangible outcomes, not confined to digital or physical products. This term was originally coined by Marc Hassenzahl (2010), who continually refines its definition, further enriched by contributions from other researchers in this field.

Influenced by the societal transformation from the material to the experiential in the Western world (Inglehart, 1971, 2000), in the field of HCI experience research, the focus shifted from solely pragmatic and instrumental qualities to a more comprehensive consideration that includes hedonic qualities at the beginning of the 21st century (Hassenzahl, 2004). HCI and design researchers proposed new notions of non-utilitarian concepts to broaden the perspective of experience design. These enrichments revealed that the sources of positive and meaningful experiences include fun (Draper, 1999), pleasure (Jordan, 2002), hedonic value (Hassenzahl et al., 2000), ludic value (Gaver et al., 2004) and pleasurability (Norman, 2005a). Later, researchers (Petersen et al., 2004; Lim et al., 2007; Petersen, Hallnäs & Jacob, 2008; Lenz, Diefenbach & Hassenzahl, 2014) introduced aesthetic interactions which prioritise emotions and experiences over efficiency in design practices. Researchers have debated whether experience can be designed. Kaptelinin and Bannon (2012:p.296) argued that designers can only design for an experience, but it is impossible to guarantee the emergence of a specific experience during interaction because experiences are not able to be shaped and anticipated due to their personal, situated, emergent attributes. However, Hassenzahl (2018:p.26) claimed that experience can be understood as an immaterial outcome and can be at least envisioned in an ideal form because experiences emerge from diverse elements (i.e., pragmatic qualities and hedonic qualities of a product, users' identity and cultural background, specific contexts) and sub-processes (e.g., three levels of goals for completing a task, which will be introduced in *Section 2.2.5.4*) occurring simultaneously, which can be mediated. This thesis tested the view of Hassenzahl (2018) and attempted to shape experience through designerly interventions in IoT transformations.

Table 2.4 presents the evolution of the definitions of "experience design" and highlights their significance. Fundamentally, experience design explores the strategic deployment of stimuli, the element of time and interactions to influence and mediate human behaviours, emotions and memory within specific contexts, linking positive experience to pleasure and pleasurable moments. The selection of the term "experience design" as the primary term for this thesis is underpinned by three reasons. First, it aligns closely with the core objectives of this research, which focus on shaping specific, context-driven experiences through IoT transformation, as opposed to the holistic design of UX for IoT products. Second, in the context of the IoT, where data and interactions frequently operate in the background, the concept of "experience design" is particularly relevant. It shifts away from the traditional product-centric views and recognises the crucial role of concealed data and interactions in mediating experiences and constructing narratives. Third, the theories and methods associated with experience design frequently concentrate on eliciting pleasure and pleasurable moments, addressing the importance of designing pleasurable experiences for IoT products (discussed in *Section 2.1.4*). Understanding the concept of pleasure and the existing methods to shape it is crucial for designing pleasurable experiences. The next section will discuss pleasure's meaning for humans and existing frameworks for designing pleasurable experiences.

**Table 2.4. Definitions of Experience Design (sorted by year of publication).**

| No. | Definition | Significance |
|---|---|---|
| ***1.*** | "Experience Design asserts design not to be about products anymore but about the experiences they deliver. This requires a broadened perspective, with the fulfilment of psychological needs (values), which in turn creates meaning and emotion, as the prime design objective." (Hassenzahl, 2010:p.75) | Distinguishes experience design from product-oriented UX design and clarifies that its aim is to fulfil psychological needs while fostering meaningful and emotional experiences. |
| ***2.*** | "The practice of designing products, processes, services, events and environments with a focus placed on the quality and enjoyment of the total experience" (Norman, 2013). | Clarifies what types of interventions can be conducted by designers and emphasises the role of enjoyment in experience design. |
| ***3.*** | "User Experience is just a sub-category of experience, focusing on a particular mediator – namely interactive products. If it comes to actual Experience Design, that is the question of how to deliberately create and shape experiences, a distinction between interactive products and other mediators of experiences may be helpful, but does not seem crucial." (Hassenzahl, 2013) | Further explains the relationship between UX and experience design, positing that disguising interactive products and other mediators is not important. |
| ***4.*** | "An approach which places pleasurable and meaningful moments at the centre of all design efforts" (Hassenzahl et al., 2013) | Emphasises the importance of pleasurable and meaningful moments in experience design. |
| ***5.*** | "In fact, much of what we nowadays would classify as experience design refers to these kinds of indirect experiential consequences of products and technology." (Fokkinga, Desmet & Hekkert, 2020:p.103) | Advocates for attention to the indirect experiential consequences of product and technology |

### 2.2.3 Understanding Pleasure

The previous two sections introduced "experience" and "experience design". It can be seen that designers' focus on experience design has shifted from usability to positive and meaningful experiences. From these positive and meaningful experiences, pleasure was selected as the key theme for this thesis. This section and the next will unpack the meaning of "pleasure" from a philosophical and psychological perspective and explain why pleasure was selected.

#### 2.2.3.1 Philosophical Discussions about Pleasure

European philosophers and theorists have discussed the value of pleasure throughout history (Shapiro, 2018). Plato (1999) raised two compelling criticisms of pleasure: 1) pleasure is essentially linked with pain or painful desire, and 2) pleasure is producing false belief. He also recognised a special class of pleasures (pleasures of learning and pleasures of sight and hearing) that were exceptions to these criticisms. Aristotle accounted for pleasure as the perfection of perfect activity (Hardie, 1980). In particular, he viewed pleasure as the character that activities gain when there is a specific fit between the condition of the activated capacity and the object it relates to (Strohl, 2018). Western philosophers and theorists in the later Middle Ages (like Thomas Aquinas) considered pleasures as passions of the soul, instead of the sensory powers and the intellect (Pickavé, 2018). Aquinas believed that desire satisfaction was a necessary condition for pleasure and agreed with Aristotle's idea that pleasure could be the perfection of an activity (Pickavé, 2018). He tried to distinguish different types of pleasures – pleasure and joy, pleasure of hope and the pleasure of memory. Seventeenth-century priest Nicolas Malebranche (1997) positioned pleasure as centrally involved in sensory perception, helping to structure human representations. He believed pleasure tracked how the world related to humans, sustaining continued human existence, and in this regard, pleasure represented a human good.

Seventeenth-century Bishop George Berkeley (1999) argued that pleasure, pain and perceptions of sensible qualities were merely subjective sensations. He believed that sensations were integral to physical objects and that humans could understand the nature and existence of these objects through their sensations, including pleasure. The eighteenth-century agnostic philosopher Kant (1991) moved away from thinking of pleasure and pain as mere sensations and developed an account that takes pleasure as rational. In this account, sensory pleasures depended on practical reason, and aesthetic pleasures were conscious (Kant, 1998).

In the nineteenth century, philosopher and economist John Stuart Mill (2009) proposed a version of Utilitarianism in which utility was defined as pleasure itself and the absence of pain. According to Mill's philosophy (especially within the Associationist psychological theory that he developed under the influence of his father, James Mill, and philosopher, jurist and social reformer Jeremy Bentham), the content and function of pleasure depend on its role in scientific induction (Mill, 1869). Mill argued that pleasure might be able to induct other mental states, explain actions and be physiologically explained. Contemporary philosophers regard philosophical theories that place pleasure at the centre, such as Mill's utilitarianism, as "hedonism" (Weijers, 2021). Michel Onfray (2015) defined pleasure as an attitude of introspection for ethically gaining pleasure and bringing pleasure to others. He suggested people should balance their pleasure and that of others and consider from different perspectives – political, ethical, aesthetic and historiographical – when pursuing it. He wanted a small group of people who shared his hedonistic worldview to stimulate micro-revolutions. From a philosophical perspective, pleasure is deeply intertwined with pain, as the two often define and influence each other. Despite this complex relationship, pleasure remains a powerful motivator of human behaviour. Throughout history, people have continuously reflected on whether the pursuit of pleasure is ethically justifiable.

### 2.2.3.2 Psychological Discussions about Pleasure

The philosophy discussions above indicate that pleasure is related to experience and sensations. Shifting to psychology, "pleasure" becomes a technical term. Pleasure is associated with descriptive terms like "pleasant", "agreeable", "liked", "likeable", "attractive" and "nice", used for a positive evaluation of sensations, objects, actions, people and events (Fredrickson, 2001). From a psychological perspective, pleasure or pleasant emotions offer several benefits for human beings. Pleasure facilitates the field of positive psychology, which developed after the Second World War. The discipline focuses on what makes lives worth living rather than only curing people. Seligman and Csikszentmihalyi (2000) argued that pleasure is a fundamental condition for examining positive psychology, which aims to promote human flourishing. Flourishing is often described as achieving optimal human functioning and realising one's fullest potential or becoming the best version of oneself (Ryan & Deci, 2001).

Diener and Lucas argued that subjective well-being consists of three components: life satisfaction, the presence of positive mood and the absence of negative mood, which are collectively often referred to as happiness. Notably, Frijda (2009) argued that psychologists have historically been misled by three guises of pleasure: that it occurs as a subjective state (e.g., Ruckmick, 1936); that it occurs in the form of an experienced property of sensations, objects, actions, people or events (e.g., Arnold, 1960; Ruckmick, 1936); and that it is embedded in emotions (e.g., Davitz, 1969). Frijda (2009) claimed that the nature of pleasure is instead a stable state of acceptance and a process of acceptance tuning. "Acceptance tuning" refers to a subject adjusting to accept emerging stimuli and events, including their personal state; to be ready to fit the current perception of the stimulus; and as a result, to experience the object or event as pleasant. Her later work (Frijda, 2017) distinguished different pleasures by listing six kinds: 1) non-sensory likings, 2) pleasures of gain and relief, 3) achievement pleasures, 4) social pleasures, 5) activity pleasures and 6) aesthetic pleasures; all of which follow the process of acceptance tuning. Frijda (2009) believed pleasure to be elicited from the potential of exerting the functions of the organism or person, from progress in successfully exerting these functions and from the successful completion of these functions when no aversive processes were restraining these functions and generating pain. According to Frijda (2009:p.109), the overall function of pleasure results in a tendency to continue the present interaction with an object or situation or to stay within the present interaction.

It is important to acknowledge the relationship between emotions and pleasure. Plutchik (1980) developed the wheel of emotions (Figure 2.4), which categorised emotions into primary emotions and different intensities. This framework is useful for understanding how emotions evolve and interact within psychological and evolutionary contexts. He maintained that primary emotions are a result of evolutionary progress, and the typical reaction to each emotion is likely to maximise the chances of survival. Among the eight primary emotions – anticipation, joy, trust and surprise – are associated with pleasure. Russell (1980, 2003) introduced a 2D circular model of "core affect" (Figure 2.5) that combines affective dimensions with physiological arousal to categorise emotions. This model simplifies the complex landscape of human emotions and helps to understand how emotions operate. In this model, the terms "pleasant" and "unpleasant" label the bipolar horizontal axis representing the valence dimension. The emotions that fall on the positive side of the valence dimension, such as excited, elated, happy, contented and serene, are often associated with pleasure. Remarkably, pleasure itself is not categorised as an emotion in either model; however, positive emotions can induce feelings of pleasure. Experience design methods (Desmet, 2012; Yoon et al., 2021) have been built on positive emotions. To summarise the psychological discussion regarding pleasure:

pleasure is not an emotion but rather a feeling or state that results from various emotional experiences. It encompasses a cluster of positive emotions and the fulfilment of various psychological needs. Consequently, in this thesis, the term "pleasure" is used to describe a range of experiences where people feel positive emotions or their psychological needs are met.

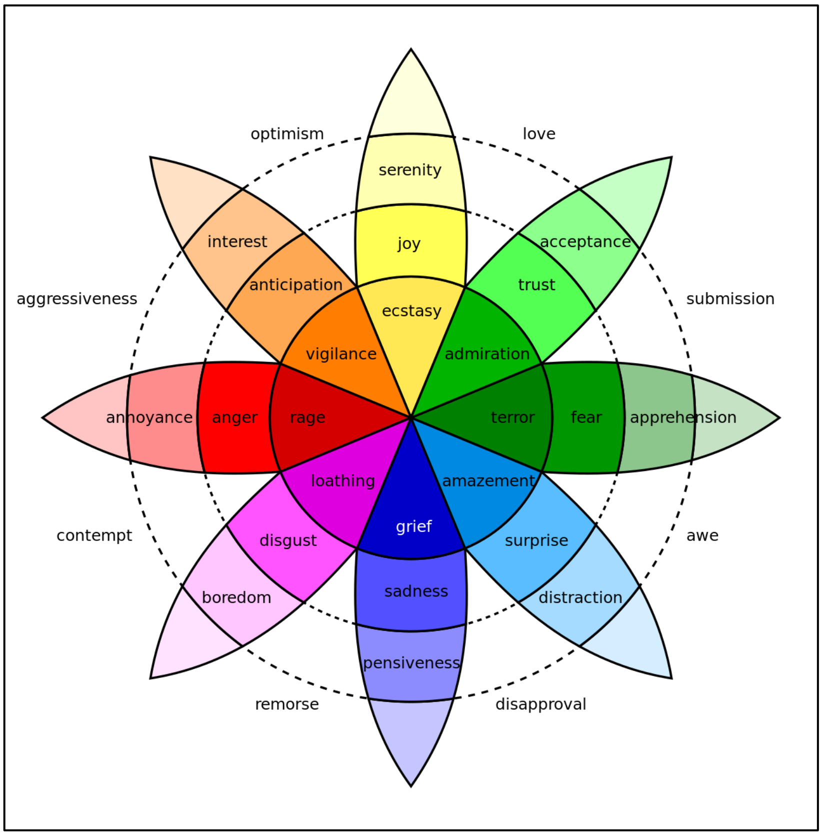


**Figure 2.4 Plutchik's wheel of emotions (1980) - This model encompasses eight primary bipolar emotions: joy versus sadness, anger versus fear, trust versus disgust and surprise versus anticipation. The intensity of the emotions increases as one moves closer to the centre of the wheel and decreases moving outward.**

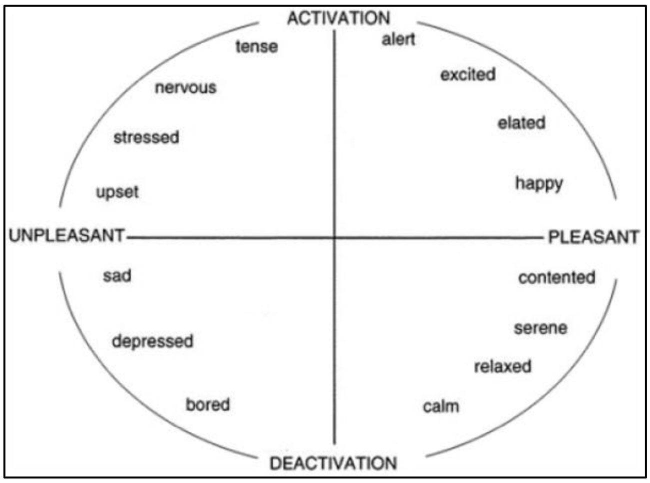


**Figure 2.5 Russell's 2D circular model of "core affect" (2003) - This model represents emotions along two dimensions: 1) The horizontal axis "Valence" ranges from pleasant to unpleasant feelings, capturing the degree to which an emotion is perceived as pleasant or unpleasant. 2) The vertical axis "Arousal" ranges from deactivation to activation, indicating the level of activation associated with an emotion.**

### 2.2.4 Pleasurable Experiences and Pleasure-Driven Design

When Dewey proposed the notion of aesthetic experiences, it already included concerns of pleasurable elements. In Dewey's view, pleasure is an enhanced form of commonplace, prosaic experiences in which the interaction between the experiencer (or experiencers) and the experience's subject is exceptionally pleasant and creative. As introduced in *Section 2.2.2*, the societal shift from the material to the experiential in the Western world has led researchers to propose new non-utilitarian experience design theories within HCI and design. Hassenzahl et al. (2000) proposed the separation of hedonic and pragmatic qualities in experiences based on psychological theories (Ryan & Deci, 2001). Hedonic quality pertains to "a product's perceived ability to create 'pleasure' through use" (Hassenzahl, 2018:p.18). Jordan (2002) argued that consumers' product needs had evolved beyond mere functionality and usability, now including the pursuit of pleasure. Experience design pioneer Norman also advocated focusing on the pleasurability of products:

"It is not enough that we build products that function, that are understandable and usable, we also need to build joy and excitement, pleasure and fun, and yes, beauty to people’s lives. (Norman, 2004:p.312)”

He later proposed emotional design, which made the hedonic qualities, beauty, emotions and joy acceptable to the HCI and interaction design field. Hekkert (2006) used the term “aesthetic experience” to refer to the pleasure derived from sensory perception, which distinguished it from experiences at the cognitive and emotional levels. Later, in the product experience framework (2007) developed with his colleague Desmet, they included the experience of meaning and emotional experience along with aesthetic experience, further expanding the scope of pleasure. Desmet and Hassenzahl argued that designing for a pleasurable life (hedonics), “implies the design of products that are direct sources of pleasure by creating or mediating pleasurable experiences rooted in human values and evidently pleasurable activities (2012:p.10)”. They proposed “possibility-driven design”, which encouraged designers to move the focus from a problem-solving approach to creating new possibilities that brought users happiness and meaning. Hassenzahl et al. (2013) developed a method that designs momentary pleasurable and meaningful experiences from experience patterns. Similar advocacy can also be found in the domain of aesthetic interactions (Lim et al., 2007; Petersen, Hallnäs & Jacob, 2008; Petersen et al., 2004), which emphasises placing emotions and experiences before efficiency. This approach calls for designers to thoroughly understand users’ emotions and experiences before shaping the design, ensuring seamless integration with products’ functions and the context of use.

Desmet and Pohlmeyer (2013) developed the positive design framework which advocates designing for pleasure, personal significance and virtual, thereby facilitating subjective well-being. Diefenbach, Kolb & Hassenzahl’s work (2014) further examined existing HCI studies of hedonic experiences and called for the development of methods to design for hedonic quality and to understand the circumstances in which hedonic experiences are effective. Hassenzahl et al. (2015) found that users' needs fulfilment and positive affective experiences were strongly related to products' hedonic qualities but not significantly linked to their pragmatic ones. Ryan and Deci (2001) identified two psychological approaches to well-being: the hedonic approach, which equates well-being with pleasure attainment and pain avoidance, and the eudaimonic approach, which defines it through meaning, self-realisation and personal functioning. Mekler and Hornbæk (2016) distinguished eudaimonic experiences from hedonic experiences and argued that the former influences long-term well-being while the latter affects momentary pleasure. Design researchers (Desmet & Pohlmeyer, 2013; Ozkaramanli, Özcan & Desmet, 2017; Hassenzahl, Burmester & Koller, 2021) have advocated for balancing momentary pleasure and long-term well-being in the development and practices of experience design methods. Initially, the practices within this thesis focused on momentary pleasure, as it is more directly related to the immediate experiences users have after interacting with an IoT system. However, both the hedonic and eudaimonic qualities of IoT products will be discussed based on reflections on design practices. Hassenzahl, Burmester and Koller (2021) reviewed the experience design theories developed over the past twenty years. The paper argued that the transition of designers' focus from usability to affective experience has progressed more slowly than expected. It advocated for designers to critically question the purpose of certain systems by utilising models, processes, metrics, studies and principles and to seek alternatives in experience design. Taking this suggestion into account, the practices within this work will challenge established experience design frameworks and processes.

#### 2.2.4.1 Defining "pleasurable experiences" and "pleasure-driven design"

In this thesis, "experiences" pertain to affective experiences that users derive from a product, whereas “pleasurable experiences” especially refer to the momentary pleasure elicited from hedonic qualities (Diefenbach, Kolb & Hassenzahl, 2014; Hassenzahl et al., 2000, 2015) of a product. These hedonic qualities are not directly task-related and may include attributes such as originality, innovativeness and novelty. In the HCI community, experiences sometimes include a product’s ease of use and task efficiency. However, from a combined design and HCI perspective, this thesis solely discusses the affective experiences that are influenced by products. I employ the adjective “pleasurable” to distinguish it from the term “positive experiences” (Desmet, 2012; Desmet & Pohlmeyer, 2013; Hassenzahl et al., 2015), which typically includes both momentary pleasure and long-term well-being.

Within HCI and design communities, terms like “data-driven design” (Gorkovenko et al., 2020), “experience-driven design” (Olsson et al., 2013) and “possibility-driven design” (Desmet & Hassenzahl, 2012) have been used to describe design methods that are oriented towards a particular key factor. In this thesis, “pleasure-driven design” refers to the experience design methods that prioritise users’ pleasure. Although many existing experience design methods aim to create pleasurable experiences, there is no comprehensive term to encompass them. Therefore, I propose “pleasure-driven design” as an umbrella term for methods focused on designing interactive products that serve as direct sources of pleasure within the context of experience design.

### 2.2.5 Pleasure-Driven Design Frameworks

The previous sections have introduced the discipline of experience design and the role of pleasure in human experience. This section will introduce four existing pleasure-driven design frameworks that influenced this research. For reflecting pleasure-driven purposes, influential and well-established experience design frameworks that prioritises pleasure-related experiences were deliberately selected.

### 2.2.5.1 Jordan's Hierarchy of Consumer Needs

Jordan's hierarchy of consumer needs (2002) is an experience design framework that explicitly addresses the concept of pleasure with the aim of designing pleasurable products. In this hierarchy, he identified three distinct levels of consumer needs, progressing from the most basic to the most sophisticated: functionality, usability and pleasure (as illustrated in Figure 2.6). Functionality represents the fundamental understanding of what a product will be employed for and the specific context and environment in which it will find utility. Usability pertains to the degree of ease with which a product can be utilised. Pleasure encompasses the emotional, hedonic and practical benefits associated with products (Jordan, 2002:p.12). Practical benefits include the advantages derived from accomplishing tasks for which the product is intended, while emotional benefits arise from the influence that a product exerts on an individual's mood. Hedonic benefits, meanwhile, cover the sensory and aesthetic pleasures that products offer.

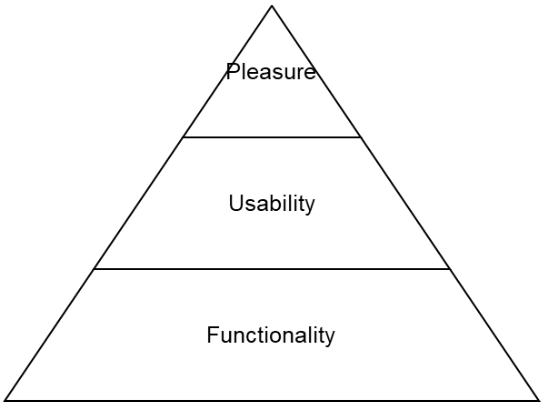


**Figure 2.6. Jordan's hierarchy of consumer needs (2002:p.5).**

Jordan emphasised that the scope of human factors extends beyond mere usability, providing a holistic understanding of the interactions between people and products. This perspective established a connection between the benefits that a product delivers and its inherent properties, thus facilitating pleasurable experiences. Drawing inspiration from Lionel Tiger's framework outlined in the book "The Pursuit of

Pleasure" (Tiger, 2000), Jordan (2002) identified four categories of pleasure (as presented in Table 2.5) – physical, social, psychological and ideological – and transposed them into the context of product design. This categorisation serves as a valuable theory for this thesis, effectively breaking down the multifaceted concept of pleasure regarding products into four distinct dimensions. During the design process, this categorisation enables designers to address the diverse forms of pleasure that users may derive from a product. It is essential to note that not all products necessarily provide all four types of pleasure. Some products offer a wide spectrum of pleasurable experiences, while others may be appreciated for specific types of pleasure they afford. When it involves IoT products, physical pleasure can relate to tangible interactions with them, socio-pleasure can be influenced by the connectivity of IoT products, psycho-pleasure can be affected by the meanings of the data collected, and ideo-pleasure can relate to the privacy and security concerns of IoT and the calls for sustainability in HCI.

**Table 2.5. Four types of pleasure modified from Jordan (2002).**

| **Pleasures** | **Description** |
|---|---|
| ***Physio-pleasure*** | Relates to the body and pleasures derived from the sensory organs. They include pleasures connected with touch, taste and smell, as well as feelings of sensual pleasure. |
| ***Socio-pleasure*** | Enjoyment derived from relationships with others, e.g., relationships with friends and loved ones, with colleagues or with like-minded people. |
| ***Psycho-pleasure*** | Psycho-pleasure pertains to people's cognitive and emotional reactions. |
| ***Ideo-pleasure*** | Ideo-pleasure pertains to people's values. |

### 2.2.5.2 Norman's Three Levels of Emotional Design

Norman's framework (2005b) revealed how users emotionally react to a product and provided a full spectrum of emotional experiences. He posited that the emotional experiences associated with everyday products are complex and influenced by multiple factors. Some of these factors are controllable, manipulated by designers or manufacturers, or even shaped by product advertising. However, there is another dimension to these experiences that derives from within, stemming from the user's private, personal encounters. Norman's insights were inspired by the complex workings of the human brain, which he divided into three primary levels of processing: the visceral level (an automatic, pre-wired layer), the behavioural level (responsible for regulating everyday actions) and the reflective level (the contemplative aspect of cognition). Figure 2.7 visually presents these three levels of processing and their respective impacts on people's sensory and motor responses. At the visceral level, the affective process starts by rapidly forming judgments about whether something is positive or negative. It then transmits signals to motor systems and alerts the rest of the brain. The biological determinations at this visceral level can be either restrained or stimulated by signals from the levels above. The behavioural level, in turn, generates most human behaviours, and it can be influenced by the reflective layer and can, in turn, affect the visceral layer. The highest reflective level does not have direct connections to sensory input or control over behaviours, but it can monitor, respond to and even manipulate the behavioural level.

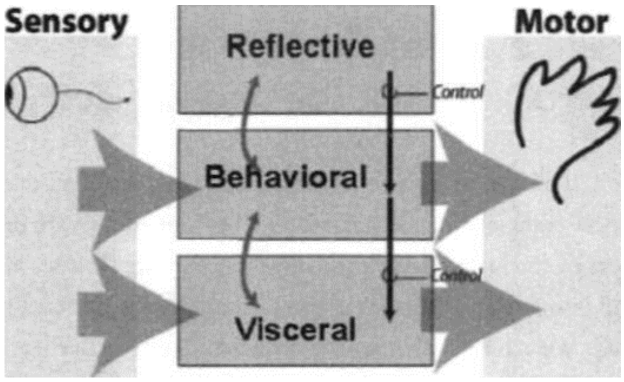

**Figure 2.7. Norman's three levels of emotional responses to design (2005b:p.22).**

Drawing from the framework of these three levels of processing, Norman proposed a design paradigm termed "emotional design", comprising three corresponding levels of design: visceral, behavioural and reflective. Norman claimed that all three design levels held significance but required distinct approaches for shaping them. Visceral design is about creating the initial impression of a product that aligns with people's inherent desires. Designers, based on the target users and their cultures, employ their visual and graphic skills to create effective visceral designs. This aspect of design emphasises immediate emotional impact, drawing inspiration from the shapes, forms and textures of materials. Behavioural design is concerned with the holistic user experience, including performance, function, understandability, usability and physical feel. Designers should regard behavioural design as a fundamental component of their user-centred design projects, involving an iterative process: studying user behaviour across diverse contexts, comprehending user needs, rapid prototyping, incorporating testing feedback and gradually refining prototypes. Reflective design, on the other hand, explores the designer's interventions pertaining to self-image, personal satisfaction and memory. Users' overall impression of a product largely stems from their reflective-level experiences based on the total appeal and experience staying in their memory. Pleasure-driven design through IoT transformation can be considered across three levels: in visceral design, considering the aesthetic change when analogue products transformed into IoT; in behaviour design, considering how these transformations influence the behaviours of people who interact with IoT; and in reflective design, considering how sensemaking of data collected by IoT influences their reflective thinking.

### 2.2.5.3 Desmet and Hekkert's Framework of Product Experience

Desmet and Hekkert (2007) developed a comprehensive framework for understanding product experiences, specifically focusing on affective responses induced by human interaction with a product (as depicted in Figure 2.8). Unlike the broader scope encompassed by Jordan (2002) and Hassenzahl (2010), their framework centres exclusively on affective experiences. Within this framework, they introduced three distinct types of product experiences: aesthetic experience, experience of meaning and emotional experience. The aesthetic experience pertains to the product's capacity to satisfy the user's sensory modalities. It focuses on how a product appeals to the user's senses, which is referred to as the visceral level of emotion design in Norman's framework (2005b). The meaning level is concerned with how users attribute expressive characteristics to a product such as personality and assess the product's personal or symbolic significance in their lives. The emotional level involves the affective phenomena in emotion psychology triggered by users' assessment of the relational meaning associated with products. Importantly, these levels are interconnected; one level can activate the others. For example, experiences of meaning can elicit both emotional experiences and aesthetic experiences, and vice versa.

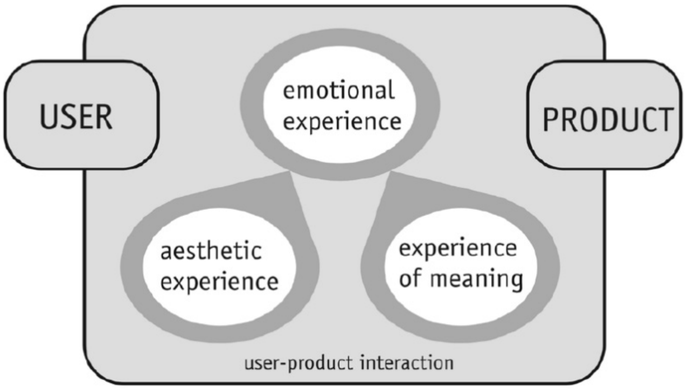


**Figure 2.8. Desmet and Hekkert's framework of product experience (2007:p.4).**

Within this framework, Desmet and Hekkert particularly highlighted two hierarchical relationships: the relationship between the emotional level and the aesthetic level, and the relationship between the emotional level and the meaning level. The meaning of a product can be viewed as an appraisal of a user's concerns, and experiences of meaning have the potential to evoke emotions. Furthermore, individual perceptions of meaning can vary, resulting in diverse emotional responses. Aesthetic experiences can also elicit emotional experiences because individuals are motivated to seek aesthetically pleasing products and avoid those that do not meet their aesthetic standards. Moreover, Desmet and Hekkert acknowledged that product experiences vary among individuals and across cultural contexts. This hierarchical relationship provides valuable insights for later design practices, suggesting that designers can shape the emotional experiences of IoT products by mediating aesthetic experiences and the experience of meaning.

#### 2.2.5.4 Hassenzahl's Hierarchy of Goals and Psychological Needs

Hassenzahl (2010) proposed experience design as a holistic, goal-directed system structured within a hierarchy. In his model (Figure 2.9), he simplified this hierarchy into three levels: "motor goals", "do goals" and "be goals", progressing from the lowest to the highest level. Motor goals, the lowest level, align with what interaction designers typically focus on – the sub-goals beneath the do goals. These goals address how users interact with a product to complete a task. For instance, when sending an email (a do goal), motor goals encompass actions like using a laptop, typing on a keyboard, and reading text displayed on the screen. Do goals are centred on the specific tasks that users can accomplish during their interaction with a product. These goals are not limited by technology, as multiple methods can lead to their achievement. For example, sending an email could be a do goal achieved through various devices such as mobile phones, tablets or laptops. At the most complex level, be goals explore why users engage with products. Designers must consider how a product alters users' perceptions, motivations and cognitive processes. Be goals serve to motivate user behaviours and imbue meaning into their actions. Hassenzahl advocated that modern HCI researchers employing experimental approaches must broaden their perspective beyond do goals and factor in be goals, the underlying reasons for interaction. He integrated Activity Theory (Carver, Scheier & Weintraub, 1989) into his three-level hierarchy model (Figure 2.10). The highest level, "be goals", consists of activities appropriate to fulfilling particular motives. On the "do goals" level, activities consist of goals and the corresponding actions to achieve them. On the "motor goals" level, actual actions comprise operations that are highly dependent on the given conditions.

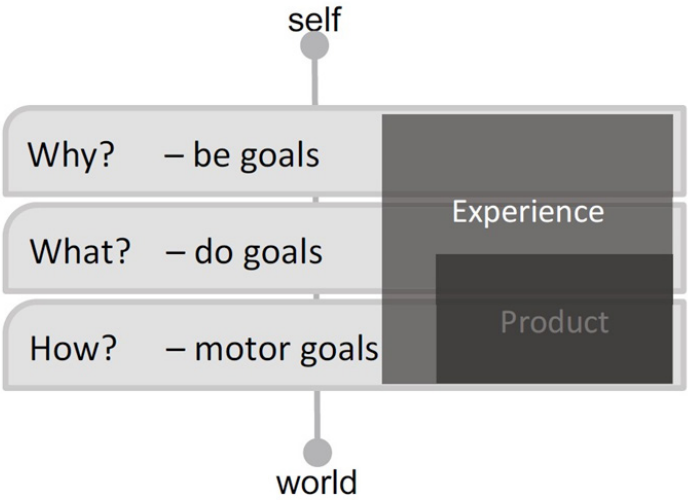


**Figure 2.9. Hassenzahl's three-level hierarchy of goals for experience design (2010:p.12).**


**Figure 2.10 Hassezahl's three-level hierarchy of goals for experience design integrating Activity Theory (2010:p.44).**

Hassenzahl et al. (2000) differentiated between hedonic qualities and pragmatic qualities of a product. In his hierarchical framework (Hassenzahl, 2010), the top-level be goals are primarily determined by hedonic quality, whereas the lower-level do goals are mainly influenced by pragmatic quality. Sheldon et al.'s study (2001) highlighted the connection between the pleasantness of an experience and the fulfilment of psychological needs within that experience, such as the need for autonomy or stimulation. Hassenzahl (2010; 2013) argued that while functionality and usability as pragmatic qualities are prerequisites in product design, meeting users' psychological needs is the most critical element in fostering a positive experience. Hassenzahl (2010) identified ten universal psychological needs based on Sheldon et al.'s work (2001) (competence, stimulation, relatedness, autonomy, popularity, meaning, security and physical striving), which constitute crucial components of the user-product interaction experience. The fulfilment of psychological needs is tied to specific products, engendering emotions and meanings during interactions. Subsequently, Hassenzahl et al. (2015) identified six psychological needs most likely to be elicited by interactive products (see their explanations in Table 2.6) and found that users' needs fulfilment and positive effects were strongly related to products' hedonic qualities but not significantly linked to their pragmatic ones. Notably, Krajewski (2017) pointed out that all of the psychological needs defined by Sheldon et al. clash with the features of IoT as IoT brings insecurity, dependency, loss of control and privacy to users. The thesis will assess Krajewski's argument through design practices.

**Table 2.6 Six psychological needs elicited by interactive products (Hassenzahl, 2010; Hassenzahl, Diefenbach & Göritz, 2010; Hassenzahl et al., 2015).**

| Needs | Description |
|---|---|
| ***Relatedness*** | Feeling that you have regular intimate contact with people who care about you rather than feeling lonely and uncared of. |
| ***Meaning*** | Feeling that you are developing your best potential and making life meaningful rather than feeling stagnant and that life does not have much meaning. |
| ***Stimulation*** | Feeling that you get plenty of novelty and stimulation rather than feeling bored and under-stimulated by life. |
| ***Competence*** | Feeling that you are capable and effective in your actions rather than feeling incompetent or ineffective. |
| ***Security*** | Feeling safe and in control of your life rather than feeling uncertain and threatened by your circumstances. |
| ***Popularity*** | Feeling that you are liked, respected, and have influence over others rather than feeling like a person whose advice or opinion nobody is interested in. |

Observing these frameworks together, it can be seen that all of them categorise experiences in a hierarchical structure, with positive psychological experiences always at the top level. However, these frameworks were developed before the proliferation of IoT products and focused on addressing desirable experiences for users. Therefore, the applicability of these frameworks to IoT products needs to be validated. My published survey studies (Lin, Sommer & Ahmed-Kristensen, 2021; Lin et al., 2023) (referred to as Surveys 1 and 2 and introduced in *Sections 4.1.1 and 4.1.2* of this thesis) have demonstrated that Jordan's four types of pleasure and Hassenzahl's six psychological needs are relevant to a typical IoT product (smartwatches). These theories provide effective categories for comparing the pleasurable experiences of IoT products with their analogue forms (traditional wristwatches). Table 2.8 shows a comparison of four frameworks from the perspectives of three types of interactions in an IoT network: interactions between things and humans, interactions between things and interactions between humans (International Telecommunication Union, 2005). From the comparison, it is evident that none of the frameworks have yet considered the interactions between things, which exposes a potential issue for designing experiences of IoT products with existing frameworks. Without considering interactions between things, designers might ignore a key factor of IoT products, the agency of things in their creation processes. My published work (Lin, Hall & Sommer, 2022) (referred to as Workshop 2 and introduced in *Section 4.2.2* of this thesis) involved a workshop with 25 early-career designers and tested Jordan's hierarchy of consumer needs. The findings illustrated that while this framework can serve as a guideline for these designers to conduct pleasure-driven design for an IoT product's experience, it is insufficient for linking design theories with unique features of IoT products.

**Table 2.7 A comparison of the four frameworks in terms of three types of interactions within an IoT system.**

| **Framework** | **Interactions between Humans and Things** | **Interactions between Humans** | **Interactions between Things** |
|---|---|---|---|
| ***Hierarchy of Consumer Needs (Jordan, 2002)*** | √ | √ | x |
| ***Three Levels of Emotional Design (Norman, 2004)*** | √ | x | x |
| ***Framework for Product Experience (Desmet & Hekkert, 2007)*** | √ | x | x |
| ***A Hierarchy of Goals in User Experience (Hassenzahl, 2010)*** | √ | x | x |

## 2.3 Pleasure-Driven Design for IoT Transformations

### 2.3.1 The Influence of IoT Transformations on Pleasure-driven Experience Design

After understanding the meaning of pleasure and the methods to shape it in experience design, it is necessary to explore how IoT influences pleasure-driven design before developing new methods. The experiences of IoT products differ from those of analogue products and purely immaterial products, such as digital services. Rowland et al. (2015) summarised the differentiation of how IoT products can be experienced as follows:

- functionality can be distributed across multiple devices with different capabilities,
- the focus of the user experience may be on the service,
- we do not expect internet-like glitches from the real world,
- IoT is largely asynchronous,
- code can run in many more places,
- devices are distributed in the real world,
- remote control and automation are programming-like activities,
- complex services can have many users, multiple UIs, many devices, many rules and applications,
- many differing technical standards make interoperability hard, and
- IoT is all about data (Rowland et al., 2015:pp.1–16).

Rowland et al. (2015) pointed out that while IoT products aim to deliver a holistic service, they can be significantly impacted by hardware. Utilising multiple hardware components can be advantageous for running complex algorithms and processing large volumes of data. However, this complexity may negatively affect the user experience due to potential instability. The variation in experiences across different IoT products indicates that designers must consider interactions among multiple devices and users, ensuring they function cohesively as a system to deliver a positive holistic experience. According to Rowland et al., experience design for IoT products in the industry involves several components: UI/visual design, interaction design, interusability, industrial design, service design, concept models, productization and platform design. The multidisciplinary nature of IoT experience design indicates that pleasure-driven methods need to be explicitly developed to address these diverse components effectively. Rowland et al.'s arguments present the complexity that IoT transformations bring to pleasure-driven design and highlight the differences in experience between IoT products and traditional analogue products. Building on this foundation, my published survey studies (Lin, Sommer & Ahmed-Kristensen, 2021; Lin et al., 2023), referred to as Surveys 1 and 2 and detailed in *Sections 4.1.1 and 4.1.2* of this thesis, compared pleasurable experiences between wristwatches and smartwatches, which identified the influence of IoT transformations in terms of four types of pleasure (Jordan, 2002) and six psychological needs (Hassenzahl et al., 2015). The other studies within this research further explored how designers can harness the power of both the service and hardware of IoT products, transforming the complexity of IoT into opportunities to create pleasurable experiences.

Dunne (2006:p.100) pointed out that electronic products have the potential to create unique narratives and encourage socialisations through user engagement, while also imposing social and behavioural constraints. Within the HCI and design communities, several studies have explored how IoT products mediate user experiences. Researchers have employed various types of IoT interactions to create novel experiences and test them with users. Worthy et al. (2016) utilised a semi-functional probing tool to simulate IoT objects, exploring doubts and concerns about living with IoT devices and their role in environmental sensing. Their findings highlighted that the collection and use of data were key factors influencing people's trust in IoT devices. Lindley et al. (2017) developed a design fiction to illustrate how the experiences of a kettle change when it is transformed into an IoT device, viewed from an object-oriented perspective. Pschetz et al. (2017) created an IoT coffee machine to explore user perceptions of data transactions in an IoT system. Rebaudengo et al. (2019) designed IoT toasters that competed with other toasters within a network, which encouraged user engagement and fostered a bond between the products and their users. Gaver et al. (2022a) developed self-build IoT devices called Yo-Yo Machines, which express signals such as lights, sounds or simple mechanical movements to facilitate distant communication between people during the COVID-19 pandemic. Collectively, these studies demonstrate that IoT transformations can be utilised by designers as a material for shaping experiences through design interventions. The novelty of these approaches in provoking and evaluating IoT product experiences with participants has inspired this work, suggesting that focusing on specific IoT products and scenarios is an effective method for understanding how pleasurable experiences can be mediated by IoT transformations.

### 2.3.2 IoT Creativity-Supporting Tools

The large paradigm shift from analogue products to IoT products facilitates the generation of specific IoT creativity-supporting tools, which provide insights and inspiration for developing a new method for designing pleasurable experiences through IoT transformation. Kurze et al.'s work (2020) compared seven IoT design creativity-supporting tools, namely Cards'n'Dice (Berger et al., 2019), co-create the IoT (van Kranenburg et al., 2014), IoT Design Deck (Dibitonto et al., 2018), IoT Design Kit (De Roeck et al., 2019), KnowCards (Aspiala, 2014), MappingTheIoT (Vitali & Arquilla, 2018) and Tiles IoT Toolkit (Mora, Gianni & Divitini, 2017) and mapped them onto the four phases of the Double Diamond Framework (Design

Council, 2019). Among these tools, Cards'n'Dice, Mapping IoT and Tiles IoT toolkits are relevant to this research as they specifically target designers, while the other tools have a stronger focus on end-users, multidisciplinary experts and/or companies. Cards'n'Dice is a toolkit that includes a pair of artefacts: "Loaded Dice" (an IoT device in the form of a dice) contains different actuators and sensors, and a set of cards for brainstorming scenarios for IoT products and services, regardless of technical issues. KnowCards are a set of cards providing descriptions of components for generating new ideas about selecting components. The MappingTheIoT Toolkit is a comprehensive IoT design toolkit comprising paper-based materials to support multidisciplinary teams. It covers four phases of the Double Diamond and five design dimensions, from developing ideas to evaluating them. The Tiles IoT Toolkit consists of cards, a canvas and a playbook that helps non-expert audiences gain a basic understanding and quickly ideate new IoT products mostly neglecting further details. Moreover, Chen et al.'s The IoT Deck (2011) incorporates a category called "emotion", encouraging designers to consider the emotional needs of the user during the design process and highlighting the emotional value of IoT products.

De Roeck et al.'s paper (2014) compared two creativity-supporting tools for IoT: tangible business process modelling (tBPM) (Luebbe & Weske, 2012) and Lillidots (De Roeck et al., 2012). Lillidots consist of a collection of template sheets for imagining the applications of a fictitious object (lillidot) without any technical constraints. The tool was specifically designed for the ideation and conceptualization of connected products. In contrast, tBPM is a more general approach that focuses on establishing actor networks, using four types of shapes to map out various elements of a system. Lillidots proved to be more effective in supporting designers to immerse themselves in their design activity, while tBPM showed its advantage in strengthening collaborations. De Roeck et al. found that a creativity support tool for designing IoT products should be actor-centred, allow expression in multiple ways, balance tangible and service components and trigger detailed interaction definitions. Additionally, Lockton et al.'s Design with Intent toolkit (2010a, 2010b), which uses a design pattern to help designers in ideation for behaviour change, provides further inspiration. Although not specifically designed for IoT products, this toolkit was applied in a workshop with design students who redesigned six household objects to save energy. Participants transformed objects into IoT forms inspired by the toolkit (Lockton, Harrison & Stanton, 2013), which illustrated that IoT transformation can facilitate behaviour change, thereby shaping experience. The experience gained from these existing tools has enabled me to develop a new method that supports pleasure-driven design through IoT transformations, which will be introduced in *Section 5.1.1*.

## 2.4 Summary

This literature review explored IoT transformations, outlining the key concerns in design and HCI regarding these transformations, comparing features, capabilities and agency of various categories of IoT products, and highlighting the importance of designing for pleasurable experiences and the deficiencies in current IoT experiences. A specific definition of "IoT products" for this thesis is proposed. The inherent immaterial data and connectivity of IoT products differently affect people's experiences compared to analogue products, revealing significant design and research opportunities in experience design. However, existing IoT products often lack sufficient pleasurability due to their development focusing on technology, hardware and profits, as well as the concealing nature of data collection practices. Consequently, the methods adopted in this research aim to identify the specific differences between an IoT product and its analogue form to uncover new design opportunities and improve the pleasurability of IoT transformations.

In my analysis of the definitions of experience, UX, experience design and UX design, I established that this thesis would focus on the broader concepts of experience and experience design rather than narrowly on UX. I explored the concept of pleasure from philosophical and psychological perspectives, leading to my understanding of pleasure and a refined definition of "pleasurable experiences" specifically for this thesis. Within this context, I introduced the term "pleasure-driven design" as the central theme, discussing the benefits and limitations of existing frameworks. This evaluation identified a research gap: current pleasure frameworks do not fully account for the types of interactions enabled by IoT products, suggesting a need for new methods to adapt pleasure-driven design to IoT transformations. The methods employed in the practices of this research need to identify the deficiencies in existing frameworks and provide insight for the development of a new one.

I explored how IoT transformations influence pleasure-driven design and reviewed existing IoT creativity-supporting tools. The influence of IoT transformations suggests that pleasure-driven design for IoT transformation requires integrating the experience design of physical products and digital interfaces, allowing designers to deliver novel experiences by experimentally mediating interactions within IoT systems. An examination of current IoT creativity-supporting tools highlighted how designers can be supported in creating IoT experiences and transforming analogue products into IoT forms, inspiring the development of a new framework (in *Section 5.1.1*). The new framework should incorporate the advantages of existing tools and emphasise pleasure-driven design theories. In design practices, methods should be designed to evaluate the new framework by engaging designers and experts from relevant fields. Combining all theoretical insights in the literature review, this research aims to explore new possibilities for pleasure-driven design enabled by IoT transformations. Before proceeding to the design practices, a robust methodology will need to be developed to guide the research process effectively, detailing the criteria for selecting methods suited for exploring pleasure-driven design and IoT transformations.

# 3. Methodology

## 3.1 Researcher’s Position

As Gaver et al. (2022b) suggested, the methods, goals and even topics of practice-based design research often emerge during the process. This research embraced an emergent methodology and adopted a mixed methods approach, with methods planned in response to each study’s findings. Instead of detailing the entire methodology here, I will present a general overview of the quantitative and qualitative methods that can be integrated into a mixed methods approach with the specific details unfolding in Chapters 4 and 5, which introduce the practices. After all the practices have been introduced, a comprehensive overview of the methodology will be provided along with the reflections for developing it in *Section 6.3*. The research was structured into three stages, each addressing a sub-research question. The researcher’s role varied across these stages: in Stage 1, acting as an observer, I examined and compared users’ pleasurable experiences using an IoT product and its analogue form using quantitative methods. In Stage 2, I acted as an experimenter and organiser, conducting participatory design and experimenting with existing pleasure-driven approaches alongside design practitioners to evaluate their effectiveness. In Stage 3, I adopted the dual role of researcher-designer, applying pleasure-driven design theories to create physical prototypes as probes.

The following sections of this chapter will explore emergent methodology, epistemology, the research through design approach and the mixed methods approach, highlighting the methodology’s objectives and considerations as the research progresses. Moreover, this section will discuss participatory design as a category of potential research methods, examining its strengths and limitations. Details on how specific methods emerged as recognised needs informed by the findings of previous studies will be further interpreted in *Chapters 4 and 5*.

## 3.2 Emergent Methodology

Gaver et al. (2022b) reported a tendency in practice-based design research to embrace emergent methodologies and noted that all accounts of design and design research (citing Frayling, 1994; Gaver, 2012; Koskinen, Binder & Redström, 2008; Zimmerman, Forlizzi & Evenson, 2007) maintain at least a degree of emergence in their approaches. Building the methodology as the research progresses, rather than establishing it at the beginning, allows the emergent methodology to demonstrate its strengths. It facilitates the identification of new perspectives and insights, particularly in unpredictable research contexts such as "wicked problems" (Rittel & Webber, 1973; Buchanan, 1992) without compromising rigour – a rigour that is attentive to clues. If researchers ignore emergence in their methodology, they risk being off the point, adhering too rigidly to their initial intentions and missing real opportunities. This thesis adopted an emergent methodology due to the unpredictability of results from experience design and the complex interactions between humans and IoT products as well as the influence of COVID-19. An emergent methodology allows this research the flexibility to explore new possibilities in experience design through IoT transformations. Notably, a significant period of this research overlapped with the COVID-19 pandemic, leading to the emergent selection of methods to address the constraints imposed by this exceptional situation. These considerations will be elaborated in Chapter 4, which introduces the specific studies. To manage emergence, Gaver et al. (2022b:pp.522–523) recommended that design researchers understand emergence in terms of research programmes as well as projects, emphasise design in setting and be mindful of emerging directions that may contribute. Following these suggestions, this thesis examines the emergence in terms of each project as well as the broader pleasure-driven design programme. It also emphasises design in project setting for applying designer practitioners' skills in research projects. This includes both the participants in my studies who are designers and myself, as my role in this research shifts between a design-researcher and a designer. The next chapter will present design practices as a journey, narrating its emergence and enhancing its readability to the audience.

Once all the practices are finished, the emergence observed in this thesis will be assessed following three suggestions from Gaver et al. (2022b:p.524). First, by recognising starting points as provisional, I will discuss my new understanding of pleasure in the context of IoT based on the results of design practices. Second, by assessing output on their terms, the thesis will consider not only the collective contribution of all practices but also the contributions of each project. Third, by valuing agility and responsiveness, this thesis will critically discuss its emergent methodology post-practices, appreciating all emergent aspects and their implications for other researchers. Considering the limitations of an emergent methodology, Gaver et al. (2022b:p.521) pointed out that emergence might be inhibited if researchers introduce intent-bound elements into design research to facilitate communication with the HCI community and its technical neighbours such as scientists and engineers. Therefore, practice-based design researchers need to find ways to frame, evaluate and communicate their emergent design practices. This thesis adopts an emergent methodology and frames the research in a way that contributes to both design and HCI fields through designerly interventions. How designers can contribute to the HCI field through a research-through-design approach will be introduced in *Section 3.5*. After confirming an emergent methodology, the supporting epistemology of this research will be discussed in the next section.

## 3.3 Epistemology

To frame the methodology, two widely adopted epistemologies – positivism and constructionism – have been considered and compared (see Table 3.1). After careful evaluation, both have been included to underpin this research.

**Table 3.1 Comparisons of positivism and constructionism based on Ramanathan (2008).**

| | **Positivism** | **Constructionism** |
|---|---|---|
| ***The observer*** | Must be independent | Is part of what is being observed |
| ***Human interests*** | Should be irrelevant | Are the main drivers of science |
| ***Explanations*** | Must demonstrate causality | Aim to increase general understanding of the situation |
| ***Research* progresses *through*** | Hypotheses and deductions | Gather rich data from which ideas are induced |
| ***Concepts*** | Need to be operationalised so that they can be measured | Should incorporate stakeholder perspectives |
| ***Units of analysis*** | Should be reduced to the simplest terms | May include the complexity of "whole" situations |
| ***Generalisation through*** | Statistical probability | Theoretical abstraction |
| ***Sampling requires*** | Large numbers selected randomly | Small numbers of cases chosen for specific reasons |

Positivism represents the traditional form of research and posits that knowledge should be gained through a scientific method based on careful observation and measurement in an objective way (Creswell, 2009; Collins, 2010). It adopts a deterministic perspective, emphasising causes determining effects and outcomes (Creswell, 2009:p.6). Positivism follows a deductive approach that focuses on empirically verifiable facts about reality and excludes human interests such as free will or emotion (Collins, 2010:p.38). Quantitative methods are typically employed in studies that adhere to the positivist research philosophy. Researchers rely on data, evidence and rational considerations to make claims and shape knowledge. Initially, a positivist quantitative method was employed for the first two studies in Stage 1 of this research, as methods were developed to quantify experiences for measurement and comparison. However, positivism was deemed unsuitable for subsequent studies as it views the world as external and objective, adopting a value-free stance. This is misaligned with the research focus on human interests, particularly pleasurable experiences and psychological needs, which are central to design practices. Thus, the creative and novel perspectives of experience required for this research cannot be adequately captured through quantitative methods alone.

In contrast, constructionism (also known as social constructivism) is an epistemological view that places emphasis on the subjective interpretation of meanings constructed by social actors as they interact with one another and their environment in a social context (Creswell, 2009; Collins, 2010). Constructionism highlights the process of interpreting subjective meanings of human experiences in relation to specific objects or things, influenced by historical and cultural settings (Creswell, 2009:p.8). It focuses on the reciprocal and interdependent relationship between objects in the world and social consciousness (Collins, 2010:p.40). Studies that adhere to constructivism often employ qualitative methods and utilise open-ended questions to collect participants' opinions. Researchers position themselves in the field to gather data and interpret its meaning based on their own experiences and background. The constructivist perspective aligns well with design practices within this research, which seeks to explore the meaning of human experiences within a specific context – pleasurable experiences delivered by IoT products transformed from analogue products. Throughout these practices, diverse interpretations will be constructed, involving multiple social actors: the IoT products themselves, people engaged in interactions, designers and design and HCI researchers.

## 3.4 Research through Design

This research adopted a Research through Design (RtD) approach as an overarching framework, which has significant influence in both design and HCI research. Given the interdisciplinary nature of my research, which bridges the fields of design and HCI, this section explores the implications of RtD in both communities.

The earliest interpretation of RtD can be attributed to Christopher Frayling (1994), who identified three types of research in the field of design: research for design, research through design and research into design. Research for design involves conducting research as a means of designing a product; research through design entails design activities and designed artefacts as key elements that facilitate the generation and communication of knowledge; and research into design focuses on investigating design itself, such as design history, design tools and design methods. Frayling's (1994) notion of RtD was built on Schön's reflective practice (1984), wherein practitioners reflect both during the action as it occurs and afterwards, as well as on Lewin's Action Research (1946), which involves planning, acting and reflecting on the results of the action. Cross (1999) argued that knowledge generated in design research can be situated in the product created by designers. In his later work (Cross, 2001), he explored the relationship between science and design and posited that designers should cultivate their own intellectual culture distinct from that of scientists and artists. Horvath (2007) classified three types of academic design research that fall between basic research and design practice: research in design context, RtD (also known as design-inclusive research) and practice-based research (see Figure 3.2). "Research in design context" aligns closer to "basic research" as it applies theories and methods from established disciplines, but with the aim of addressing design-related objectives. In contrast, "practice-based research" aligns closer to "design practice", as designers reflect on a series of design projects to extract general insights, where the primary motivation is always a design outcome with knowledge serving as a secondary benefit. RtD occupies the middle ground, where the ultimate goal is the generation of knowledge while design plays a significant role in the process. Stappers and Visser (2014) distinguished two approaches within RtD: the theory-driven approach and the phenomenon-driven approach, based on the role of the prototype and the reflections derived from the design practice (see Figure 3.1). In the former, design researchers develop prototypes as stimuli to test their hypotheses based on existing theories. In the latter, design researchers primarily focus on creating prototypes and reflecting upon them with theories serving as a supplementary component.

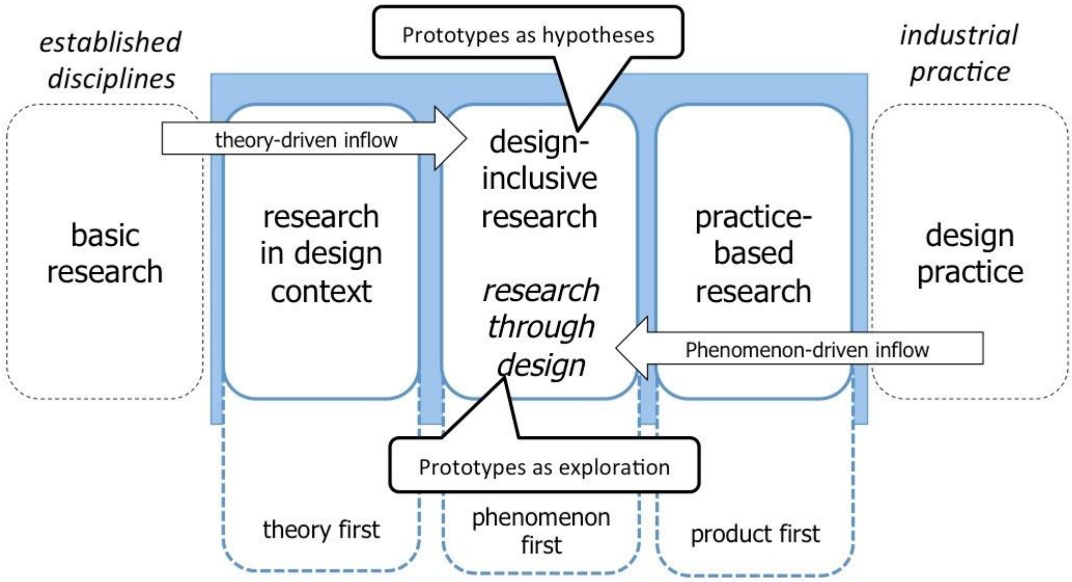


**Figure 3.1 Horvath's (2007) three methodological approaches in design research (central box) and Stappers and Visser's (2014) two approaches based on the role of the prototype and reflections from design practices.**

Stappers (2007) argued that the act of designing in research can advance knowledge across multiple disciplines. Insights gained from design practice can be novel not only within the field of design but also in other related domains. Additionally, the knowledge generated from a design practice can be reused, shared and captured in various ways. The introduction of RtD to HCI communities stemmed from the recognition of the crucial role of design in HCI research. Initially, design activities in HCI were primarily associated with usability engineering. However, Löwgren (1995) introduced the concept of "creative design", which emphasises continuous reflection on actions taken in HCI practices, distinguishing it from traditional engineering design approaches. Fallman (2003) asserted that HCI is inherently design-oriented because design and design thinking assist engineers and behavioural scientists in creating improved prototypes that showcase their research contributions. HCI researchers subsequently realised that design researchers can help address under-constrained problems within the HCI domain. Zimmerman, Forlizzi and Evenson (2007) pioneered a new model for interaction design research within HCI, highlighting the contributions of design researchers to the HCI research community. They summarised three beneficial contributions: 1) Design researchers identify opportunities for innovation in existing technology or the introduction of new technology that will have a significant impact on the world. 2) Design researchers develop tangible objects that embody both theory and technical potential. 3) Design researchers collaborate with engineers, anthropologists, behavioural scientists and HCI practitioners to produce comprehensive research outcomes that demonstrate how the problem was reframed and how the researchers balanced the intersecting and conflicting perspectives.

According to Zimmerman, Forlizzi and Evenson's framework (2007), the main distinguishing feature of design researchers in HCI is that they function as designers and produce artefacts. They emphasised that in HCI research, the purpose of creating artefacts should be to generate new knowledge rather than serve purely commercial purposes. Furthermore, the research artefacts themselves must demonstrate significant innovation.

While both HCI research and design research utilise the RtD approach to generate new knowledge, the design research community has its own unique perspectives on interpreting and evaluating "design knowledge". Gaver et al. (2003) argued that ambiguity can serve as a valuable resource in RtD for encouraging people to engage with an artefact, generate their interpretations around an artefact and deeply consider the personal meanings associated with it. They proposed three tactics for using ambiguity:

1) Enhancing ambiguity of information: The purpose may be merely to make the system seem mysterious and thus attractive, but more importantly, it can

also compel people to join in the work of making sense of a system and its context.

2) Creating ambiguity of context: This is useful in spurring people to approach a particular system with an open mind, and more generally to question the assumptions they have about technological genres.
3) Provoking ambiguity of relationship: This can allow products and systems to become psychological mirrors for people, allowing them to try on new identities or to question their values and activities (Gaver, Beaver & Benford, 2003:pp.237–239).

In his later work, Gaver (2012) argued that RtD produces knowledge that is provisional, contingent and aspirational. He compared the scientific and design theories and highlighted that design theories are neither verifiable nor falsifiable. The nature of design theory is self-evidenced by the artefacts, which address how issues are configured in a particular scenario. Therefore, he questioned the call for agreed-upon methodological standards and a firm theoretical foundation for the RtD approach in HCI communities (Zimmerman, Stolterman & Forlizzi, 2010), as such calls would limit the creativity and value of this approach. Instead, he advocated for moderation in attempts to validate and generalise design theories, emphasising the importance of maintaining diversity within the design discipline and drawing on annotated portfolios to manifest design theory and practice. Höök et al. (2015) also believed that RtD contributes intermediary forms of design knowledge (or intermediate-level knowledge (Höök & Löwgren, 2012; Löwgren, 2013)), which exist between theories and particular instances (i.e., designed artefacts). This intermediate-level knowledge is more abstracted than particular instances but is not generalisable like theories. It encompasses various forms (e.g., single design solutions (Stolterman, 2008), annotated portfolios (Gaver & Bowers, 2012), strong concepts (Höök & Löwgren, 2012), criticism (Bardzell et al., 2012) and speculation

(Wakkary et al., 2015)), all emphasising articulations, validations and cumulations of knowledge gained from design research.

From the existing literature, it is evident that design research differs from scientific research in terms of methods, processes, knowledge outcomes, validation and replication. However, design research employing the RtD approach still enables contributions to HCI research. The knowledge generated in this research will focus on the relationship between pleasure-driven design and IoT transformations in design contexts, embodied and enacted through the outcomes of design practices. As will be presented later, the knowledge outcome will benefit both the design and HCI communities. While design researchers may not adhere to a solid paradigm, they share a set of common values (Gaver, 2012). For HCI researchers, designers' interventions reframe theories and practices in socio-technical scenarios and address under-constrained problems from a design perspective (Zimmerman, Forlizzi & Evenson, 2007).

## 3.5 Mixed Methods Approach

The research adopted a mixed methods approach as a supporting strategy for collecting data and for evaluating and validating the processes and outcomes of a series of RtD practices exploring pleasure-driven design through IoT transformations. With an emergent methodology planned from the outset, the research remained open to incorporating both quantitative and qualitative methods. This flexibility allowed me to leverage the strengths and address the inherent weaknesses of each method (Collins, 2010:p.49; Bryman, 2012:p.637), thereby enabling a comprehensive understanding of the influence of IoT transformations on pleasure-driven design from various perspectives. The decision to use a mixed methods design was driven by the need to capture both the measurable outcomes and the nuanced experiences of the participants. Quantitative methods were employed to gather numerical data and identify patterns, while qualitative methods were employed to explore participants' perceptions, motivations and contextual factors. As Bryman (2012) noted, methods that combine quantitative and qualitative approaches help offset weaknesses (p.637), provide explanations (p.641), contextualise findings (p.645) and address different research questions (p.640).

This research was structured around a series of studies, each designed to address specific aspects of the research questions. Surveys 1 and 2 in Stage 1 of this research employed a quantitative focus using questionnaires to quantify the experiences influenced by IoT transformations. In later Stages 2 and 3, qualitative methods were introduced in studies to offset the limitations of quantitative approaches and contextualise design theories. Workshops 1 and 2 relied extensively on participatory workshop methods, whereas Workshop 3 combined workshops with questionnaires and interviews. Workshop 4 integrated workshop sessions with material speculations, and the Co-speculation Experiment combined a technology probe and co-speculation with questionnaires and interviews. In Workshop 3 and the Co-speculation Experiment, quantitative methods provided an overview of participants' feedback, while qualitative methods yielded detailed insights and explained underlying phenomena. As noted in Section 3.2, this research adopts an emergent methodology in which the methods unfold as the research progresses; detailed descriptions of these methods and the reasons for their selection will be elaborated in Chapters 4 and 5, which introduce the individual studies.

After the qualitative and quantitative data were collected and analysed, integration occurred during the interpretation stage (see *Chapter 6 Discussion* and *Chapter 7 Conclusions*), where findings from the separate methods were compared and synthesised to provide a comprehensive understanding of the research questions. This approach allowed for triangulation, ensuring that the insights derived from each method mutually reinforced the overall conclusions. The following two subsections introduce and analyse the quantitative and qualitative research methods, explaining their importance to this study.

### 3.5.1 Quantitative Methods

Quantitative research is a key approach within the positivist way of knowing. It involves the collection of numerical data and adopts a deductive view of the relationship between theory and research. Often associated with a natural science approach, quantitative research holds an objectivist perspective towards social reality (Bryman, 2012:p.160). It rigorously examines hypotheses that arise from theories by gathering and analysing numerical data from respondents at selected research sites. The analysis of this data generates findings and insights critical for validating or refuting the initial hypotheses. Figure 3.2 presents a detailed overview of the main steps in ideal-typical quantitative research. The strength of quantitative methods in this research lies in their ability to numerically measure experiences and directly compare various categories of pleasurable experiences, such as Jordan's four types of pleasure (2002) and Hassenzahl's ten psychological needs (2010). However, quantitative research also has several limitations. One such limitation is its inappropriateness for studying the social world as a natural science model, due to its reliance on fixed questions that allow little room for self-reflection (Bryman, 2012:p.178). In design research, this rigidity limits both flexibility and creativity and restricts the potential for open-ended responses that could enable novel insights and possibilities. Another limitation is that it tends to reduce complex phenomena to static views through deductive reasoning, thereby ignoring the richness of reasons and meanings behind them (Bryman, 2012:p.179). However, these missed reasons and meanings can provide valuable insights that help designers understand what is happening in the real world. As a result, quantitative methods should be complemented with qualitative methods to capture the full spectrum of human experiences (Bryman, 2012:p.179; Tullis & Albert, 2013:p.158). Therefore, Stage 1 primarily employed quantitative research to understand and compare the pleasurable experiences of a representative IoT product and its analogue form. The key quantitative methods applied in this research are questionnaires (see section *4.1.1.2*), which were used in Survey 1 (see section *4.1.1*), Survey 2 (see Section *4.1.2*), Workshop 3 (see Section *5.1.2*) and the Co-speculation Experiment (see *Section 5.2.2*).

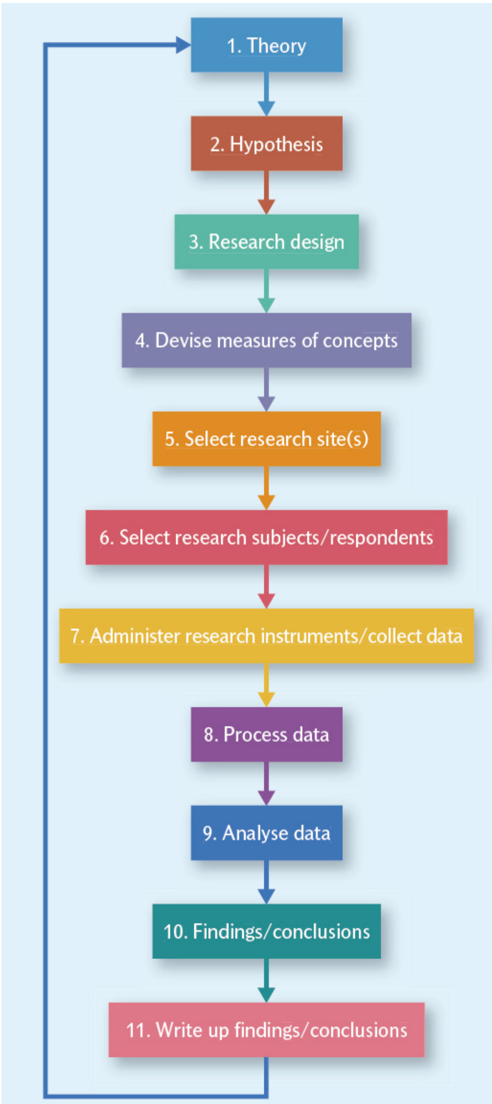


**Figure 3.2 Process of ideal-typical quantitative research (Bryman, 2012:p.161).**

### 3.5.2 Qualitative Methods: Participatory Design

Participatory design (PD) is a category of qualitative methods to be applied in practices within this thesis, engaging participants involved in IoT transformations in design activities. PD has a significant impact on the disciplines of design and HCI, as evidenced by a substantial body of literature (Schuler & Namioka, 1993; Sanders, 2002; Spinuzzi, 2005; Sanders & Stappers, 2008; Sanders, Brandt & Binder, 2010; Robertson & Simonsen, 2013; Vines et al., 2013; Bannon, Bardzell & Bødker, 2018; Farias, Bendor & van Eekelen, 2022). According to Spinuzzi (2005), PD originated in Scandinavia in the 1970s and 1980s, based on Marxist principles that aimed to involve workers in the development of new computer technologies. PD stands apart from ethnographic approaches that rely solely on observation and analysis. It emphasises the importance of researchers co-interpreting with participants throughout the entire process, seeking not only to understand participants' experiences but also to harness their expertise and knowledge in developing concepts. Sanders and Stappers (2008) noted the interchangeable usage of PD and co-design in the design research literature. Unlike traditional user-centred approaches where researchers act as translators between users and designers, PD requires a hybrid researcher-designer who assumes the role of a facilitator. This facilitator brings together diverse perspectives and knowledge to foster collective creativity (Sanders & Stappers, 2008).

As PD shows its strength in facilitating mutual learning (Robertson & Simonsen, 2013), its application in this research was motivated by the desire to engage and collaborate with designers, HCI researchers and psychologists. In the studies with this research that applied PD, I assumed the role of a facilitator to encourage participants to conduct pleasure-driven design through IoT transformations, which could not only help them gain design knowledge or inspirational insights but also contribute to my research. Sanders et al. (2010) proposed a framework which organises tools and techniques of PD by form and purpose, categorising their applications. They believed combining PD tools and techniques could maximise their strengths, and that a workshop or research plan incorporating all three types of activities – making, telling and enacting – is the most effective approach. Bannon et al. (2018) advocated for the reimagining of PD to embrace emerging new digital technologies. In recent research, PD has been continuously extended and combined with other methods in design research such as speculative design (Farias, Bendor & van Eekelen, 2022). However, PD can be hindered by many factors such as power relations and political dimensions (van der Velden & Mörtberg, 2015:p.60) as well as language, cultural factors, knowledge of technology, power dynamics and personality traits (Thinyane et al., 2018:pp.8–9). Therefore, design researchers need to adopt a critical and reflective approach to PD's principles and practices to ensure ethical design. Researchers employing PD must navigate challenges concerning inclusion, the extent of participants' agency or power, determining when "participation" should begin and end, and how "participation" is effectively achieved (Ten Holter, 2022:p.284). The specific methods under the category of PD used in this research include workshops (see *section 4.2.1.2*), interviews (see *section 5.1.2.2*), material speculation and co-speculation (see *section 5.2.1.2*) as well as technology probes (see *section 5.2.2.2*). Participatory workshops were conducted in Workshops 1 to 4 (introduced in sections 4.2.1, 4.2.2, 5.1.2, 5.2.1 respectively). Interviews were conducted in Workshop 3 (*section 5.1.2*) and the Co-speculation Experiment (section 5.2.2). Material speculation, co-speculation and technology probes were all employed in the Co-speculation Experiment (section 5.2.2). The selection and implementation of these methods will be detailed in Chapters 5 and 6, which introduce the practices.

# 4. Exploratory Practices

Upon confirming an emergent methodology, this chapter starts to explore research questions through practices. This chapter presents the exploratory practices in the initial stages, including two survey studies in Stage 1 aimed at identifying differences in pleasurable experiences between an IoT product and its analogue form, and two workshops in Stage 2 designed to understand the deficiencies of existing pleasure-driven design frameworks. Figure 4.1 shows the placement of these exploratory practices within the entire research.


**Figure 4.1 The placement of the studies presented in Chapter 4 within the entire research (corresponding studies highlighted in the red rectangle).**

## 4.1 Stage 1: Setting an Initial Direction

Stage 1 aimed to identify the differences between an IoT product and its analogue form to set an initial direction for the following practices to explore. This stage addresses sub-RQ1: "What are the differences in pleasurable experiences between an IoT product and the analogue product from which it was transformed?" The smartwatch was selected as a representative IoT product that was transformed from an analogue product (i.e., wristwatches). To compare the user experiences of two products in different categories, two surveys were conducted, employing UX metrics created with existing experience design theories to convert qualitative human experience data into quantitative data.

### 4.1.1 Survey 1: Comparing Pleasurable Experiences of Smartwatch Users to Those of Wristwatch Users

#### 4.1.1.1 Context

Based on two well-established pleasure-driven design theories (Jordan's four types of pleasure (2002) and Hassenzahl's six psychological needs elicited by interactive products (2010; 2015); see Table 2.5 and Table 2.6 in *Section 2.2.5*), Survey 1 investigated the pleasurable experiences of IoT products by comparing a representative IoT product (i.e., the smartwatch) and its analogue form (i.e., the wristwatch). This study has been published and presented as a peer-reviewed paper (Lin, Sommer & Ahmed-Kristensen, 2021) at the EAI ArtsIT 2020 conference (ArtsIT, 2020). EAI ArtsIT is an interdisciplinary conference that unites researchers, practitioners and innovators from the fields of art, design and technology to explore and facilitate the integration of these disciplines. In this study, two online questionnaires were created using Google Forms (2024) and deployed separately to wristwatch and smartwatch users. Their experiences of using both types of watches were quantitatively and qualitatively compared through data analysis. After acquiring approval from the Royal College of Art (RCA) Ethics Committee, the participants were recruited by posting the questionnaires on Reddit and by emailing RCA students.

Reddit is an online forum that has a vast number of communities with a wide range of topics. I posted two questionnaires separately under the topics: “smartwatch” and “watches”. This exploratory survey aimed to gather feedback from users’ perspectives; thus, responses from RCA and Reddit were not differentiated. As all participants used the same Google Forms links, the proportions of RCA and Reddit responses were indistinguishable. The two questionnaires collected a total of 171 responses: 87 from the wristwatch questionnaire and 84 from the smartwatch questionnaire. Of those, 80 respondents for each questionnaire who fully completed all items without uniformly selecting the same answer across the entire questionnaire were deemed valid. These participants constituted the final sample for analysis.

#### 4.1.1.2 Method: UX metrics and Questionnaire

While HCI research tends to be objective, experience is inherently subjective (Hassenzahl, 2010:pp.5–6). However, HCI researchers can employ quantitative research methods to measure and compare experiential data. One way to achieve this is by embedding UX metrics, which aim to transform subjectivity into objectivity. Tullis and Albert (2013) claimed that UX metrics can fulfil this role in promoting products to be efficient, engaging and easy to use. UX metrics need to employ consistent measurements and produce results that are observable and quantifiable, either directly or indirectly. UX metrics present aspects of the experience in a numeric format, and their value lies in identifying usability issues, evaluating improvements in product experiences, calculating return on investment and revealing hidden patterns.

Schankin et al. (2022) discussed two main approaches to measuring UX: collecting subjective feelings through questionnaires or interviews, or inferring user experience from objective measures such as gaze direction, response times, or physiological parameters. Questionnaires are commonly used in the early stages of research projects due to their efficiency, allowing for distribution to a large number of participants at a relatively low time and monetary cost (Bryman, 2012:p.233). UX metrics are typically incorporated into questionnaires by design researchers because they are easy and quick to administer, analyse and interpret. For example, Mata et al. (2017) deployed a survey to quantify user perceptions of the geometric features of vases. Desmet (2012) applied UX metrics to measure the degree of 25 positive emotions in human-product interactions, while Hassenzahl et al. (2015) employed UX metrics to explore the correlation between need fulfilments and user experience. In Stage 1 of this research, UX metrics and questionnaires are employed to measure experiences related to different types of pleasure and psychological needs to gain an understanding of the differences between smartwatches and wristwatches.

#### 4.1.1.3 Research Design

In Survey 1, I compared the influences of smartwatches and wristwatches on users' pleasurable experiences to identify if any differences exist. **Smartwatches**, connected computers in the form factor of a wristwatch, are a typical category of Hardware Sensor Platforms in the IoT ecosystem (Swan, 2012). Unlike traditional analogue or digital quartz **wristwatches**, smartwatches offer additional features brought by connectivity. Pizza et al.'s study (2016) indicated that the new features of smartwatches could both facilitate and constrain positive experiences. While smartwatches can integrate seamlessly into operational tasks and improve user experiences, they may also lead to stress and dissatisfaction due to continuous notifications and amplified work and life pressures. Previous design studies have compared smartwatches and traditional wristwatches to provide new insights. For instance, Martin (2002) identified parallels in wearability, user interface and cultural impact between traditional watches and wearable computers, suggesting that wearable computing could draw lessons from these aspects. Cecchinato, Cox and Bird (2015) interviewed early adopters of smartwatches and discovered that while smartwatches provided users with more convenience through notifications and reduced their mobile phone dependency, they cannot completely replace traditional watches due to aesthetic preferences. Lyons (2015a, 2015b) explored the usage practices of traditional digital watches to inform smartwatch design and noted the implication for aesthetics, power sources and application purposes based on traditional usage patterns.

I was interested in comparing smartwatches and wristwatches as their development …

1) … might share common development goals with other products (Martin, 2002) (e.g., smart fridges, weight scales or kettles, etc.).
2) … represents a successful product widely accepted and adopted by diverse user groups and the industry.
3) … could potentially serve as a model for the development of future products.

The relationship between smartwatch and wristwatch revealed that an IoT product and its analogue form might hold similar meanings for end-users and the usages of the latter can inform the design of the former. This comparison can inspire designers on how the transformation from analogue to IoT products influences pleasure-driven approaches.

Survey 1 included two questionnaires with UX metrics to compare experiences of two types of watches (see Appendix A for the full list of questions). Both questionnaires contained identical questions across three sections: basic information (gender, age group, nationality, country of residence, watch model), pleasurable experiences ratings, and open-ended feedback, to facilitate direct comparisons. The "pleasurable experiences ratings" section employed Osgood's semantic differential (SD) scale

(1957), a seven-point scale (−3, −2, −1, +1, +2, +3) between bipolar, contrasting adjectives (extremely unpleasurable, very unpleasurable, slightly unpleasurable, slightly pleasurable, very pleasurable, extremely pleasurable) and a neutral zero point (0, neither pleasurable nor unpleasurable). The process of Survey 1 is presented in Figure 4.2.

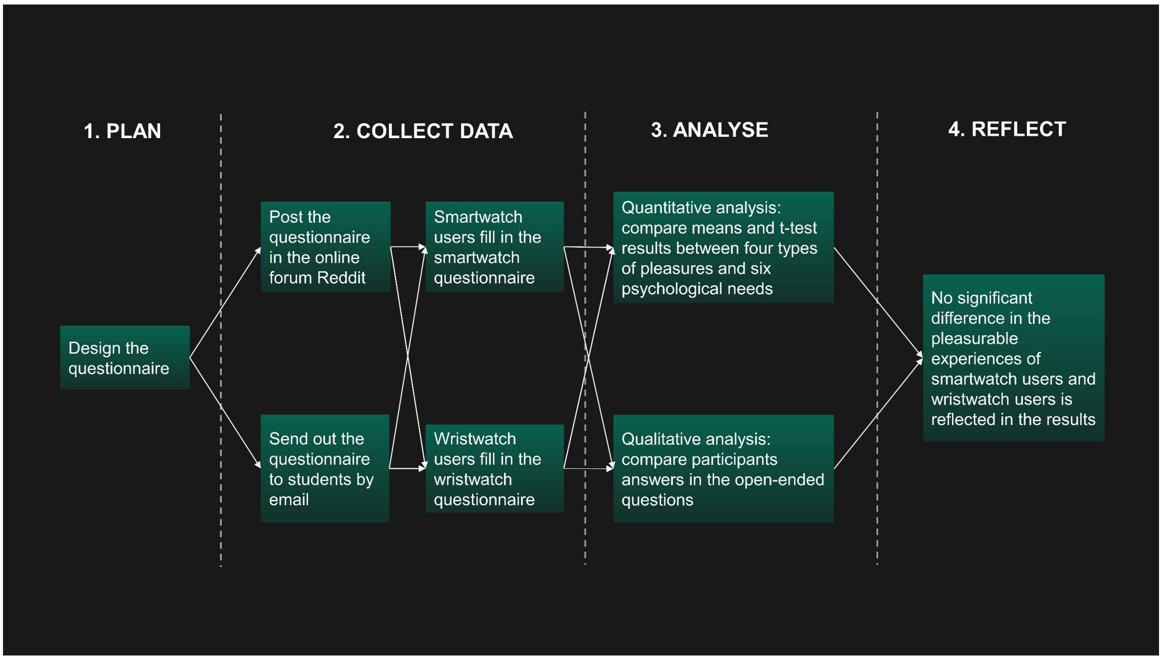


**Figure 4.2 The process of Survey 1.**

#### 4.1.1.4 Data Analysis

The online questionnaire created using Google Forms allowed me to download the results in CSV format. The data was then imported into Microsoft Excel for analysis (Figure 4.3). The COUNT function in Microsoft Excel and the formula `part/total` were used to analyse questions about participants' basic information and to calculate proportions regarding their gender, age group, nationality, country of residence, watch brands, watch models and length of use. The results are presented in the pie charts and bar charts in Appendix B.

| | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Participant idS | Timestamp | Do you have a wrist watch? | 1. What is your gender? | 2. What is your age group? | 3. What's you nationality? | 4. Which country are you currently live in? | 5. What is the brand and the model of your wrist watch? | 6. How long have you been using your wrist |
| 2 | 1 | 11/29/2019 21:22:51 | | Female | 18 - 24 | Mexican | UK | Rolex | less than half a year |
| 3 | 2 | 11/30/2019 1:12:28 | | Male | 25 - 39 | Canadian | Canada | Timex Marlin Hand-wound, Seiko Sarb, Tag Heuer Carrera ( | over 3 year |
| 4 | 3 | 11/30/2019 5:53:02 | | Male | 18 - 24 | Swiss | Switzerland | Oris Aquis source of life | 1/2 year - 1 year |
| 5 | 4 | 11/30/2019 6:54:06 | | Male | 40 - 60 | American | USA | Citizen ca 0615 | less than half a year |
| 6 | 5 | 11/30/2019 10:13:10 | | Male | 18 - 24 | Canadian | Canada | Seiko SARB033 | 1/2 year - 1 year |
| 7 | 6 | 11/30/2019 14:36:42 | | Female | 40 - 60 | British | UK | muji | over 3 year |
| 8 | 7 | 11/30/2019 18:49:23 | | Female | 25 - 39 | Danish | UK | Casio B640 Stainless steel black | 1year - 3years |
| 9 | 8 | 11/30/2019 19:27:31 | | Male | 40 - 60 | British | UK | I dont own a smart watch. My normal watch is Rotary (unal | 1year - 3years |
| 10 | 9 | 11/30/2019 22:25:37 | | Female | 25 - 39 | Italian | UK | SWATCH | 1year - 3years |
| 11 | 10 | 12/2/2019 21:48:42 | | Male | 25 - 39 | Chinese | China | Longines L4.766.4 | 1year - 3years |
| 12 | 11 | 12/3/2019 0:19:54 | | Male | 18 - 24 | Chinese | China | Gucci 11510440 | over 3 year |
| 13 | 12 | 12/4/2019 7:43:06 | | Male | 18 - 24 | American | USA | Casio A-158W | 1year - 3years |
| 14 | 13 | 12/4/2019 7:47:32 | | Male | 40 - 60 | Canadian | Canada | Zenith El Primero, Omega Seamaster Professional, Omega | over 3 year |
| 15 | 14 | 12/4/2019 7:51:10 | | Male | under 18 | Romanian | USA | (main) Wenger Men's 72800 Analog Display Swiss Quartz | less than half a year |
| 16 | 15 | 12/4/2019 8:04:02 | | Male | 18 - 24 | American | USA | Shinola Lake Superior Dive Watch | 1/2 year - 1 year |
| 17 | 16 | 12/4/2019 8:46:08 | | Male | 40 - 60 | American | USA | timex | 1year - 3years |
| 18 | 17 | 12/4/2019 8:56:13 | | Male | under 18 | Canadian | Canada | Citadel | less than half a year |
| 19 | 18 | 12/4/2019 17:08:23 | | Male | 18 - 24 | Dutch | Netherlands | Komono Winston | 1year - 3years |
| 20 | 19 | 12/5/2019 9:17:40 | | Male | 25 - 39 | American | USA | Glycine | 1year - 3years |
| 21 | 20 | 12/5/2019 9:43:51 | | Male | 25 - 39 | Canadian | Canada | Tudor - various Datejust models | 1year - 3years |
| 22 | 21 | 12/5/2019 11:56:13 | | Male | 40 - 60 | German | Germany | no idea | 1year - 3years |
| 23 | 22 | 12/5/2019 17:21:56 | | Male | 18 - 24 | Korean | Japan | Orient Defender | 1/2 year - 1 year |
| 24 | 23 | 12/5/2019 21:44:10 | | Male | 18 - 24 | Chinese | UK | Timex | over 3 year |
| 25 | 24 | 12/8/2019 0:22:47 | | Male | 25 - 39 | British | UK | Oris | 1year - 3years |
| 26 | 25 | 12/8/2019 0:34:58 | | Male | 25 - 39 | Iranian | United Arab Emirates | Vostok Komandirskie 811958 | over 3 year |
| 27 | 26 | 12/8/2019 3:08:39 | | Male | 25 - 39 | American | USA | Edifice | less than half a year |
| 28 | 27 | 12/8/2019 5:09:55 | | Male | under 18 | Canadian | Canada | Omega Seamaster professional 300m | 1/2 year - 1 year |
| 29 | 28 | 12/8/2019 5:33:09 | | Male | 25 - 39 | Canadian | Canada | Rolex Sub | over 3 year |
| 30 | 29 | 12/10/2019 3:39:05 | | Male | 18 - 24 | American | USA | Seiko 5 Sports SNHZ53 | less than half a year |
| 31 | 30 | 12/19/2019 1:02:27 | Yes | Female | 25 - 39 | American | UK | Timex, Weekender | 1year - 3years |
| 32 | 31 | 12/22/2019 22:46:02 | Yes | Male | 40 - 60 | Irish | Ireland | Seiko Alpinist SARB019 | 1year - 3years |
| 33 | 32 | 12/22/2019 22:46:59 | Yes | Male | 40 - 60 | American | USA | omega seamaster chronograph | 1year - 3years |
| 34 | 33 | 12/22/2019 22:51:03 | Yes | Male | 25 - 39 | Canadian | Canada | Seiko SKX007, Seagull 1963, Bulova Precisionist, Timex E | over 3 year |
| 35 | 34 | 12/22/2019 23:07:57 | Yes | Male | 25 - 39 | American | USA | Casio protrek prg-600yl | over 3 year |
| 36 | 35 | 12/22/2019 23:12:03 | Yes | Male | 18 - 24 | American | USA | Citizen 8700 | over 3 year |
| 37 | 36 | 12/22/2019 23:15:53 | Yes | Male | 18 - 24 | British | UK | Grand Seiko | less than half a year |
| 38 | 37 | 12/23/2019 1:02:28 | Yes | Female | 18 - 24 | Canadian | Canada | Timex | 1year - 3years |
| 39 | 38 | 12/23/2019 3:59:22 | Yes | Male | 25 - 39 | Austrian | Austria | Nixon | 1year - 3years |

Wristwatch Experience

**Figure 4.3 Raw data from Survey 1. The CSV file contains the questionnaire results from wristwatch users, imported into Microsoft Excel.**

For the rating scale questions regarding each type of pleasure and psychological need, Google Forms recorded the descriptive adjectives (extremely unpleasurable, very unpleasurable, slightly unpleasurable, neutral, slightly pleasurable, very pleasurable, extremely pleasurable) selected by participants in the CSV file. The "Replace" function in Excel was used to convert the descriptive adjectives into corresponding numerical data (extremely unpleasurable = -3, very unpleasurable = -2, slightly unpleasurable = -1, neutral = 0, slightly pleasurable = 1, very pleasurable = 2, extremely pleasurable = 3). Figure 4.4 presents an example of the data transformation process for one question from the questionnaire answered by wristwatch users. After quantifying the experience data, the AVERAGE and STDEV functions in Excel were used to calculate the means and standard deviations (SD) for each type of pleasure and psychological need. Radar charts (see Figure 4.5 and Figure 4.6) were created using the "Insert Chart" function in Excel to compare the means of four types of pleasure and six psychological needs between wristwatch users and smartwatch users.

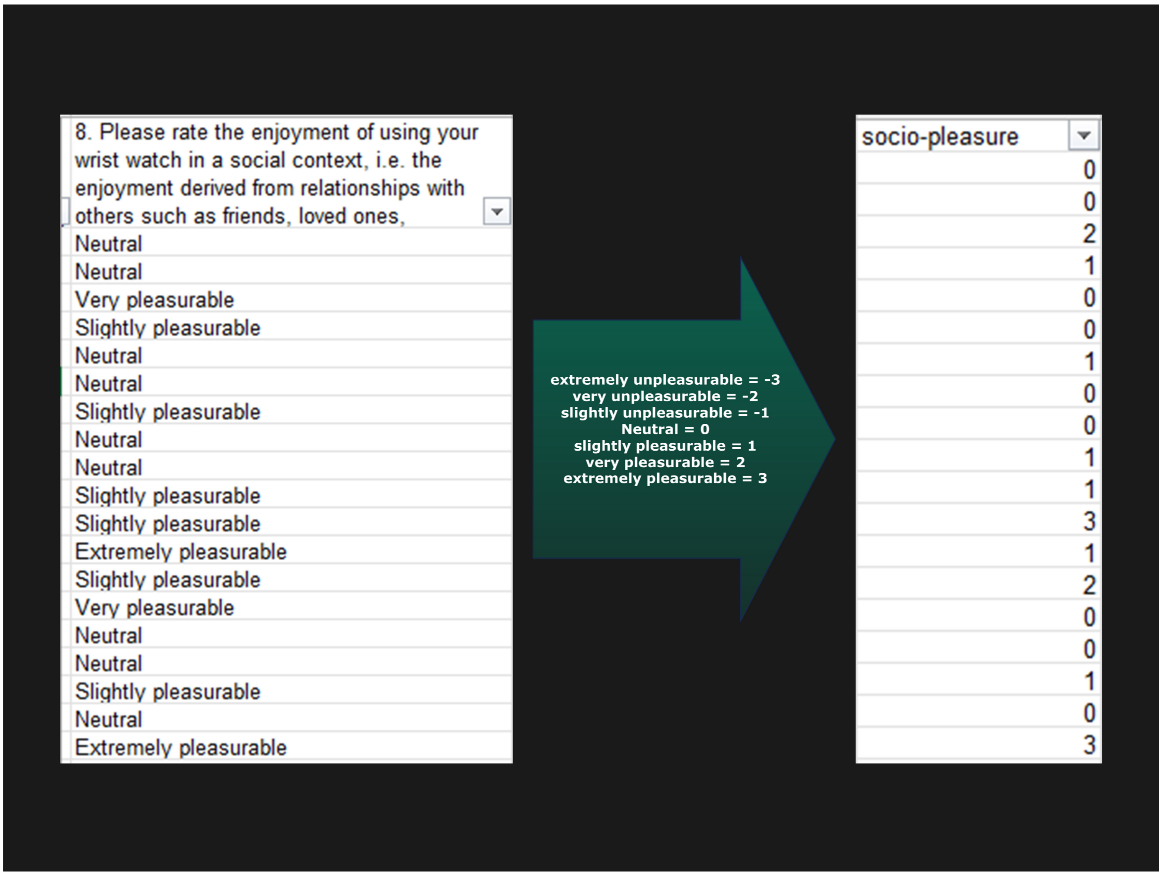


**Figure 4.4 An example of how participants' answers to rating scale questions were transformed into numerical data using the Replacement function in Excel. This question asked participants to rate their enjoyment of using wristwatches in a social context (i.e., socio-pleasure in Jordan's theory).**

T-tests were conducted to identify significant differences between the experiences of smartwatch users and wristwatch users. The VAR.S function in Excel was first used to calculate the variances of each group, and the ratios of variances were determined using the formula `Larger Variance/Smaller Variance`. The variance ratios for all types of pleasure and psychological needs were close to 1 and were thus considered equal. Subsequently, the T.TEST function in Excel was employed to perform two-tailed t-tests and obtain the p-values.

#### 4.1.1.5 Key Results

In comparing the means of four types of pleasure (see Table 4.1 and Figure 4.5) experienced by smartwatch users and wristwatch users, physio-pleasure was associated with the greatest gain, while ideo-pleasure showed the least, regardless of the type of watch. The levels of all four types of pleasure perceived by both groups were around the “slightly pleasurable” level (1). Using a Bonferroni-corrected (Dunn, 1961) alpha level of 0.013 for t-tests, the results (see Table 4.1) revealed that all p-values exceeded this threshold, indicating no statistically significant difference in the four types of pleasures experienced by the two groups.

**Table 4.1 The four kinds of pleasure compared between smartwatch users (n=80) and wristwatch users (n=80).**

| **Pleasures** | **Physio-pleasure** | | **Socio-pleasure** | | **Psycho-pleasure** | | **Ideo-pleasure** | |
|---|---|---|---|---|---|---|---|---|
| ***Watch Type*** | Smart | Wrist | Smart | Wrist | Smart | Wrist | Smart | Wrist |
| ***N*** | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 |
| ***Mean*** | 1.613 | 1.613 | 1.100 | 1.238 | 0.938 | 1.113 | 0.888 | 0.850 |
| ***SD*** | 1.248 | 1.324 | 1.228 | 1.219 | 1.095 | 1.222 | 1.453 | 1.181 |
| ***t-test (p)*** | 1.000 | | 0.497 | | 0.342 | | 0.839 | |
| Bonferroni corrected significance threshold: **α=0.013** | | | | | | | | |


**Figure 4.5 The comparison of experiences between smartwatch and traditional wristwatch users across four types of pleasure.**

Examining the means of the six psychological needs (see Table 4.2 and Figure 4.6), smartwatch users’ needs for relatedness, stimulation, competence and meaning were better fulfilled, while wristwatch users' need for popularity was better fulfilled. A Bonferroni-corrected alpha level of 0.008 was used for comparing the results of the t-tests (see Table 4.2), which showed that all p-values were above the threshold. Thus, no significant statistical differences were observed between the two groups across the six psychological needs.

**Table 4.2 The six psychological needs compared between smartwatch users (n=80) and wristwatch users (n=80).**

| **Needs** | **Relatedness** | | **Stimulation** | | **Popularity** | | **Competence** | | **Meaning** | | **Security** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Watch Type*** | Smart | Wrist | Smart | Wrist | Smart | Wrist | Smart | Wrist | Smart | Wrist | Smart | Wrist |
| ***N*** | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 80 |
| ***Mean*** | 0.763 | 0.563 | 1.150 | 0.738 | 0.263 | 0.625 | 0.975 | 0.838 | 0.875 | 0.738 | 0.938 | 0.938 |
| ***SD*** | 1.150 | 1.157 | 1.233 | 1.209 | 1.220 | 1.195 | 1.359 | 1.326 | 1.286 | 1.319 | 1.256 | 1.306 |
| ***t-test (p)*** | 0.274 | | 0.034 | | 0.818 | | 0.518 | | 0.505 | | 1.000 | |
| Bonferroni corrected significance threshold: **α=0.008** | | | | | | | | | | | | |

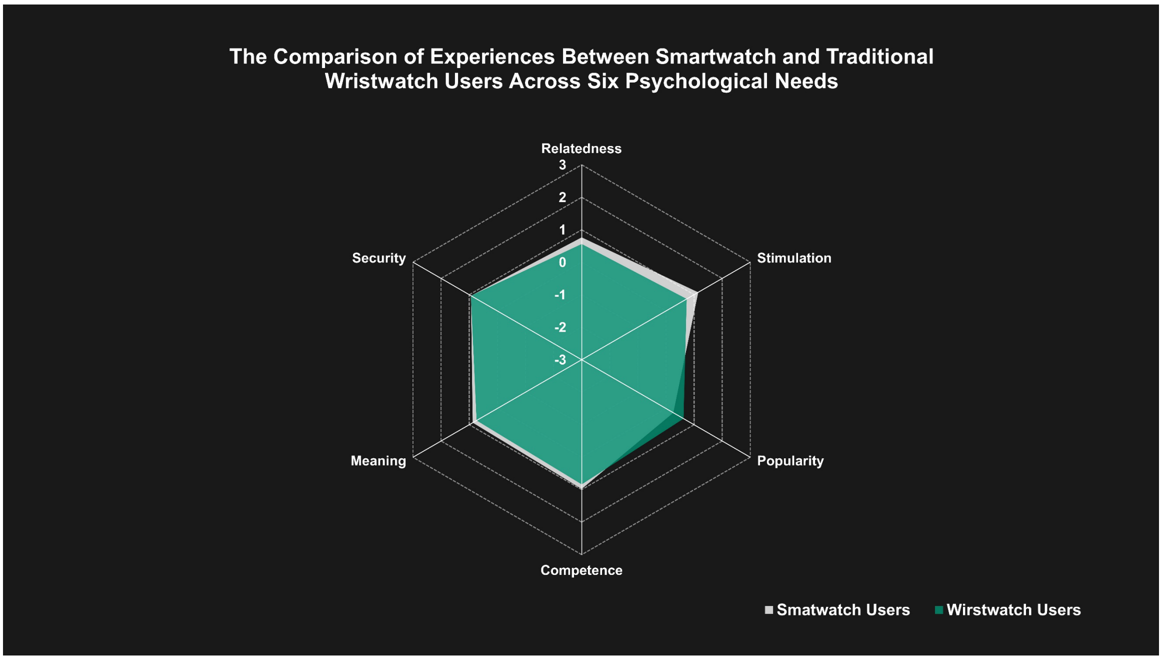


**Figure 4.6 The comparison of experiences between smartwatch and traditional wristwatch users across six psychological needs.**

In open-ended feedback, most smartwatch users cited special reasons for functionality such as sleep and health tracking and receiving notifications when unable to access their mobile phones as key reasons for using their devices. However, wristwatch users often value their watches for their aesthetic appearance and personal meaning. Interestingly, three smartwatch users (SU 18, 38 and 51) mentioned that the questions related to emotional experiences were irrelevant as they felt no emotional connection to their smartwatches at all. Although ten wristwatch users (12.5%) viewed their watches merely as tools for telling time, another four wristwatch users (SW25, 29, 30 and 50) expressed that wearing provided a sense of security and control over their time.

#### 4.1.1.6 Reflections

Unfortunately, the comparisons between the experiences of smartwatch users and wristwatch users did not reveal significant statistical differences in how an IoT product and its analogue form influence pleasurable experiences. Smartwatches as an IoT product showed no clear advantages in delivering pleasurable experiences, with users of both watch types reporting satisfaction. This result aligns with Aldossari and Sidorova's study (2020), which found that users lacking experience with IoT products often ignore the facilitating conditions of such devices and base their adoption decision on extensive experience with comparable non-IoT objects. Thus, these users saw no need for IoT products and fail to distinguish between using IoT and analogue products. In Survey 1, while smartwatch users and wristwatch users provided feedback specific to their experiences, there was no direct comparison by users who have used both types of watches. A more robust method should be developed to effectively compare the pleasurable experiences of smartwatches and wristwatches for the same group of users. Additionally, some survey questions should be reformulated to allow participants to directly compare their experiences with smartwatches and wristwatches.

#### 4.1.1.7 Summary of Findings

Comparisons between the pleasurable experiences of smartwatch users and wristwatch users in Survey 1 did not adequately capture how an IoT product and its analogue form influence pleasurable experiences differently. Therefore, the subsequent study was designed to compare the experiences of smartwatches and wristwatches among parallel users, addressing the limitations of Survey 1 and further investigating whether and how an IoT product and its analogue form impact pleasurable experiences. Notably, the use of questionnaires and UX metrics proved effective in converting experiential data into numerical form for quantitative comparisons between the two groups. Consequently, the next study maintained the survey format to compare pleasurable experiences between smartwatches and wristwatches.

### 4.1.2 Survey 2: Comparing Pleasurable Experiences between Smartwatches and Wristwatches for Parallel Users

#### 4.1.2.1 Context

Survey 2 (Lin et al., 2023) represents a revised and improved version of Survey 1, which did not reveal significant differences in pleasurable experiences between smartwatch users and wristwatch users. This study has been published and presented as a peer-reviewed paper (Lin et al., 2023) at ICED23: The 24th International Conference on Engineering Design (The Design Society, 2023). ICED is a prestigious conference in the field of engineering design that gathers researchers, academics and practitioners to discuss advancements in design theory, methodology and application while fostering collaboration within the global engineering design community. To refine the findings, I included users who used both types of watches to directly compare their experiences, ensuring a more accurate reflection of their differences. Ethical approval for Survey 2 was obtained alongside Survey 1 from the RCA Ethics Committee. Recruitment for Survey 2 was conducted similarly to Survey 1, involving postings on Reddit under the “smartwatch” topic and sending emails to RCA students. The questionnaire received 192 responses, with 130 participants deemed valid for the final sample analysis as they had completed all the questions in the questionnaire and their response time exceeded 3 minutes, which indicates thoughtful engagement. This sample includes an equal number of Western (American, Australian, Austrian, Belgian, Bosnian, British, Canadian, Danish, French, German, Greek, Hungarian, Irish, Italian, Mexican, New Zealander, Polish, Romanian, Russian, Slovenian, South African, Spanish and Turkish) and Eastern (Chinese, Malaysian, Singapore and South Korean) participants (65 in each group) to minimise cultural bias in the results. The categorisation of Eastern and Western countries was based on Huntington's theory (1998).

#### 4.1.2.2 Research Design

Survey 2 consolidated the two questionnaires from Survey 1 into a single questionnaire (refer to the details of the questions in Appendix C). The questions in the first and second parts of Survey 2 remained unchanged compared to Survey 1. However, within each question in the second part, the participants were prompted to provide their feedback for wristwatches and smartwatches respectively. The third part of the questionnaire focused on comparing participants' pleasurable experiences with smartwatches and wristwatches. They were asked to indicate the type of watch they were currently using after having experienced both options and to express which type of watch had provided them with a better overall experience. This section also included open-ended questions, allowing participants to elaborate on the reasons behind their responses. The process of Survey 2 is presented in Figure 4.7.

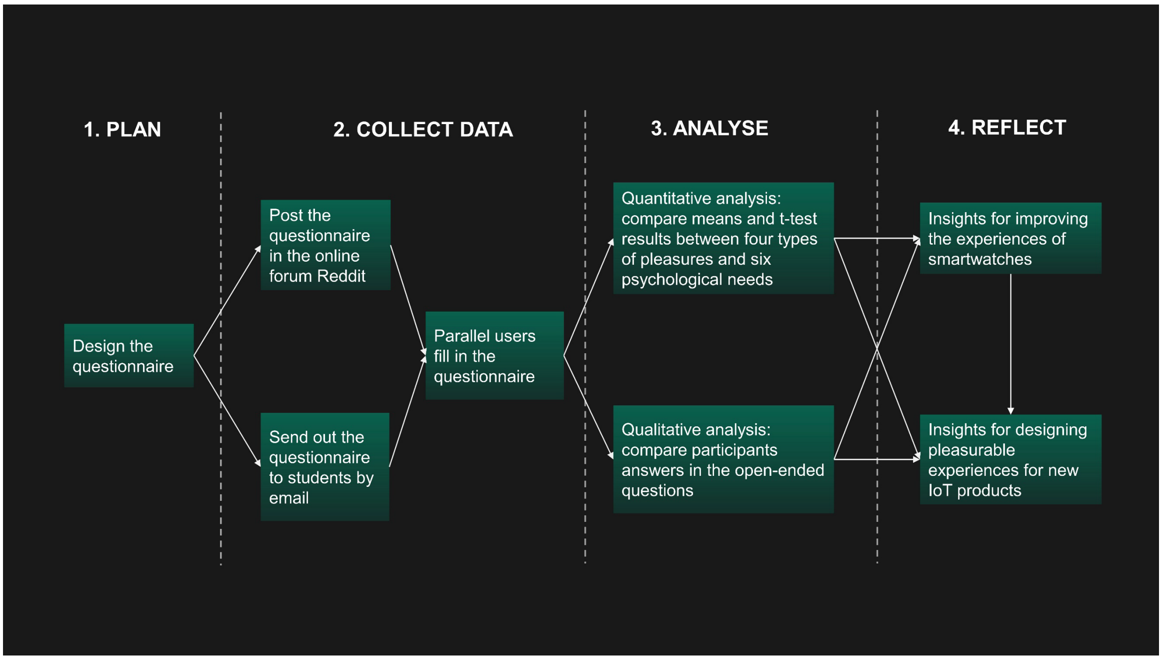


**Figure 4.7 The process of Survey 2.**

### 4.1.2.3 Data Analysis

Survey 2 collected data in the same CSV format as Survey 1, and the analysis followed the same procedure as described for Survey 1 (see Section *4.1.1.4*) using Microsoft Excel. First, proportions related to gender, age group, nationality, country of residence, watch brands, watch models and length of use were calculated. The results are presented in the pie charts and bar charts in Appendix D. Next, experience data collected from rating scale questions were transformed into numerical data, and the means and standard deviations (SD) for each type of pleasure and psychological need were calculated. Radar charts (see Figure 4.8 and Figure 4.9) were then created to compare the means of the four types of pleasure and six psychological needs between wristwatch and smartwatch users. T-tests were conducted to identify significant differences between the experiences of smartwatch and wristwatch users. Finally, I reviewed the open-ended questions one by one to select valuable responses that supported the findings from the quantitative data and provided novel insights.

## 4.1.2.4 Key Results

The comparison of means for four types of pleasure derived from using smartwatches and wristwatches (see Table 4.3 and Figure 4.8) shows that smartwatches outperformed wristwatches in eliciting all four types of pleasure. Consistent with Survey 1, physio-pleasure received the highest average ratings, while ideo-pleasure had the lowest regardless of the type of watch used. T-tests, adjusted with a Bonferroni-corrected alpha level of 0.013, present statistically significant differences for physio-, socio-, and ideo-pleasure between smartwatches and wristwatches (as shown in Table 4.3).

**Table 4.3 The four kinds of pleasure compared between smartwatches (n=130) and wristwatches (n=130).**

| **Pleasures** | **Physio-pleasure** | | **Socio-pleasure** | | **Psycho-pleasure** | | **Ideo-pleasure** | |
|---|---|---|---|---|---|---|---|---|
| ***Watch Type*** | Smart | Wrist | Smart | Wrist | Smart | Wrist | Smart | Wrist |
| ***N*** | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 |
| ***Mean*** | 1.900 | 1.538 | 1.700 | 1.162 | 1.569 | 1.262 | 0.854 | 0.238 |
| ***SD*** | 1.055 | 1.202 | 1.104 | 1.219 | 1.154 | 1.211 | 1.453 | 1.430 |
| ***t-test (p)*** | 0.011 | | 0.0002 | | 0.037 | | 0.001 | |
| Bonferroni corrected significance threshold: **α=0.013** | | | | | | | | |

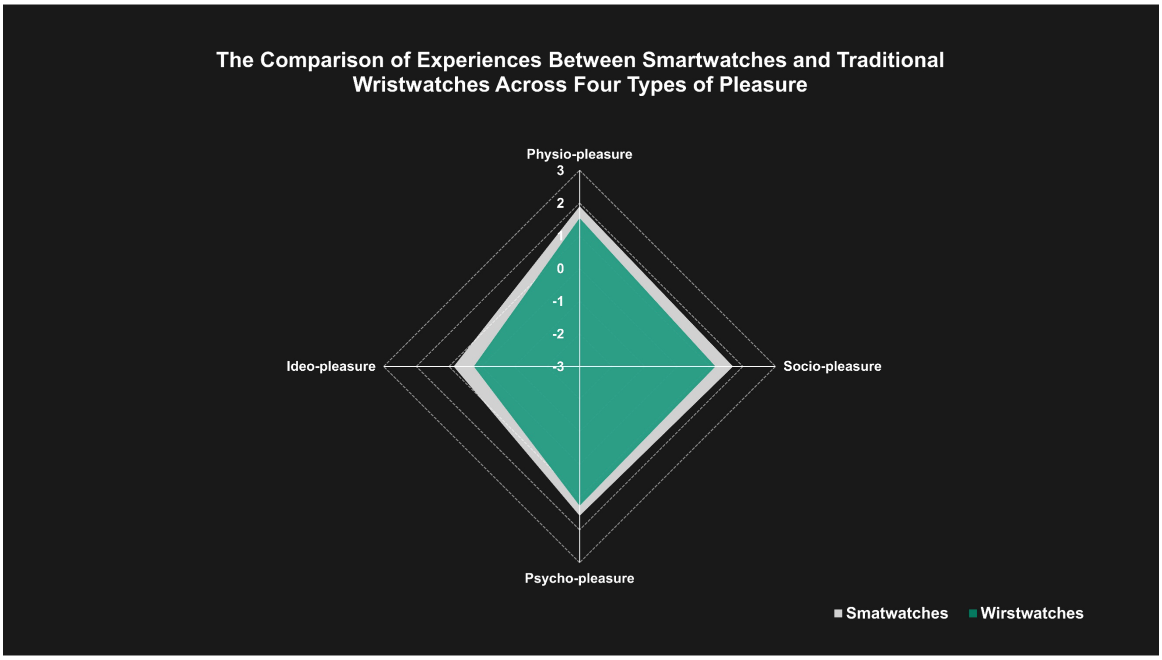


**Figure 4.8 The comparison of experiences between smartwatch and traditional wristwatch**

**users across six psychological needs.**

The comparison of means regarding the fulfilment of the six psychological needs (see Table 4.4 and Figure 4.9) suggested that smartwatches fulfilled all these needs better than wristwatches, except for popularity. Most of the psychological needs were perceived as moderately fulfilled by wristwatches, at a level just slightly above neutral (0). While smartwatches were perceived as at or above the "slightly fulfilled" level (1). However, wristwatches were less effective in fulfilling needs for relatedness and stimulation. T-tests on these needs, with a Bonferroni-corrected alpha level of 0.008, confirmed statistical significance for all but the need for popularity (as shown in Table 4.4).

**Table 4.4 The six psychological needs compared between smartwatches (n=130) and wristwatches (n=130).**

| **Needs** | **Relatedness** | | **Stimulation** | | **Popularity** | | **Competence** | | **Meaning** | | **Security** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Watch Type*** | Smart | Wrist | Smart | Wrist | Smart | Wrist | Smart | Wrist | Smart | Wrist | Smart | Wrist |
| ***N*** | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 |
| ***Mean*** | 0.938 | 0.062 | 1.362 | 0.046 | 0.292 | 0.338 | 1.169 | 0.392 | 1.085 | 0.277 | 1.177 | 0.377 |
| ***SD*** | 1.608 | 1.655 | 1.441 | 1.656 | 1.557 | 1.668 | 1.571 | 1.635 | 1.595 | 1.565 | 1.602 | 1.586 |
| ***t-test (p)*** | 0.000001 | | 0.0000000001 | | 0.818 | | 0.0001 | | 0.00005 | | 0.00007 | |
| Bonferroni corrected significance threshold: **α=0.008** | | | | | | | | | | | | |

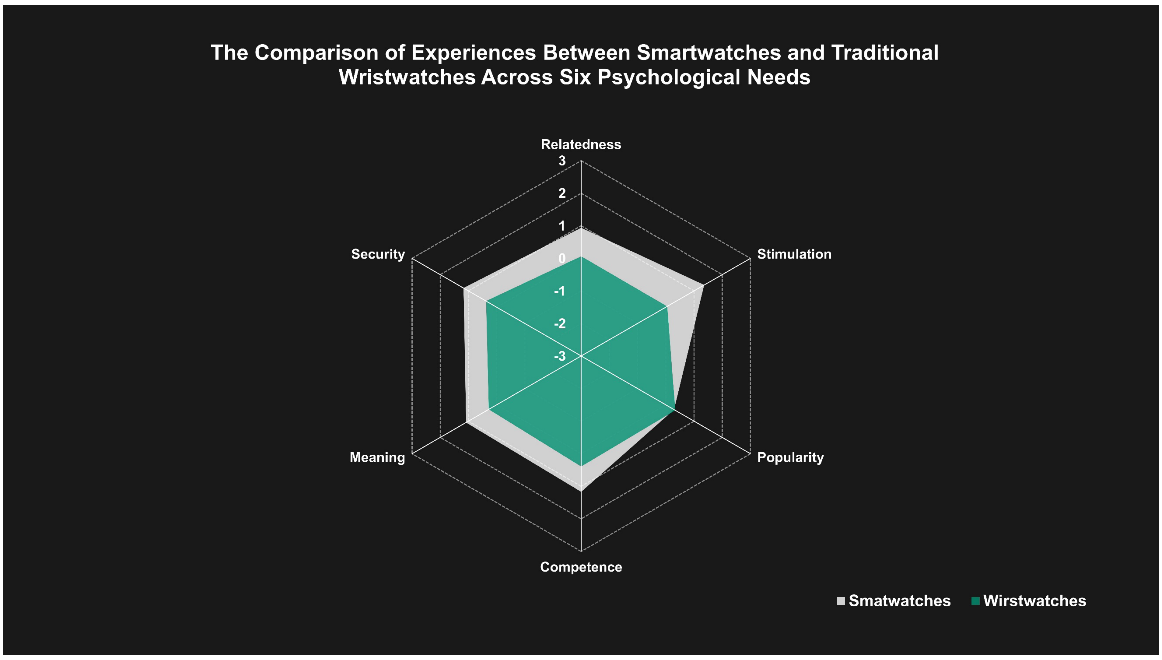


**Figure 4.9 The comparison of experiences between smartwatch and traditional wristwatch**

**users across six psychological needs.**

In the comparison of the overall experience, over half of the participants (54.61%, n=71) were exclusively using smartwatches when they responded to the questionnaire. Roughly one-third of the participants (33.85%, n=44) were using both watch types, and just over one-tenth (11.54%, n=15) were using only wristwatches. An open-ended question in the questionnaire asked why users abandoned a type of watch (if they were only using one type). Of 50 participants who had abandoned their wristwatches, 38 (76.00%) claimed they had made this decision because smartwatches offered better experiences because of their extended functionality. Meanwhile, 9 of 15 participants (60.00%) who had given up smartwatches mentioned that the inconvenience of charging had decreased pleasurable experiences.

In terms of the overall experience, 72.31% of the participants (n=94) believed that smartwatches delivered a better experience than wristwatches. When combined with the current watch they were using, the result indicated that approximately 15.38% of the participants (n=20) were still using both types, even though they thought their experiences with smartwatches were more pleasurable. In the open-ended question section, 10.77% of participants (n=14) stated that they used both types of watches on different occasions. Additionally, 6.92% of participants (n=9) mentioned the pleasurability of smartwatches due to their IoT features such as connectivity, sensing and uploading data. Participants also highlighted how smartwatches and traditional wristwatches offered pleasurable experiences in different ways. For example, participant 41 stated, "I take pleasure in the mechanics of wristwatches. I am aware of the various movements, design history and so forth. Smartwatches please me in capability, and the spectacular amount of technology they bring to bear on daily activities."

#### 4.1.2.5 Reflections

**Insights**

The results from Stage 1 addressed the sub-research question 1 "What are the differences in pleasurable experiences between an IoT product and the analogue product from which it was transformed?" Unlike Survey 1, which compared the pleasurable experiences of two products for separate user groups, Survey 2 conducted the comparison within a single user group. This approach produced contrasting results that highlighted the differences between the pleasurable experiences of an IoT product and its analogue form. The results of Survey 2 showed that smartwatches, as a representative IoT product, elicited three types of pleasure (physio-pleasure, socio-pleasure and ideo-pleasure) and fulfilled five psychological needs (relatedness, stimulation, popularity, competence, meaning and security) differently from their analogue form, wristwatches. This confirms the relevance of existing pleasure-driven design theories for emerging IoT products and suggests that designers can further explore the application of these theories to their practices. Furthermore, smartwatches outperformed wristwatches in eliciting four types of pleasure and fulfilling psychological needs. Participants noted that smartwatches offer more appealing features beyond the basic function of a watch – telling the time. This supports Hassenzahl et al.'s (2015) findings that psychological needs correlate more strongly with hedonic than pragmatic qualities. It is also noteworthy that popularity is the only attribute where wristwatches outperformed smartwatches. This may be due to the wristwatch's attribute of symbolising identity and social status (Martin, 2002).

**Limitations**

In Surveys 1 and 2, the questionnaire was sent to postgraduate students at RCA and posted on Reddit, but the survey did not inquire about participants' identities and all responses were anonymous. Therefore, it was not possible to distinguish the proportions of participants from RCA versus Reddit. However, the RCA cohort is a diverse mix of cultures from potentially over 76 nationalities, gender diversity and disciplines across design, creative industries, sciences and engineering (Royal College of Art, 2019). In Survey 2, the number of Western and Eastern participants was balanced to minimise cultural bias in the results. While efforts were made to include diverse ethnic backgrounds, the cultural influences on the results cannot be entirely eliminated. The limitation of the quantitative analysis methods in Surveys 1 and 2 is that they capture users' opinions regarding smartwatches and wristwatches narrowed down to specific aspects, but do not offer guidance for designers on the next steps or how to design for varying levels of pleasure across different use cases. Thus, the qualitative methods would be employed subsequently to explore the potential uses of IoT transformations through specific interventions.

#### 4.1.2.6 Summary of Findings

Survey 2 found that smartwatches elicited three types of pleasure (physio-pleasure, socio-pleasure and ideo-pleasure) and fulfilled five psychological needs (relatedness, stimulation, popularity, competence, meaning and security) differently from wristwatches. This finding highlighted the potential of IoT transformations as a tool for designing pleasurable experiences and inspired me to focus on these types of pleasure and psychological needs when developing a new method for pleasure-driven design through IoT transformations in the next stage. Additionally, the difficulty in explaining certain phenomena using quantitative data from Survey 2 emphasised the need for a mixed methods approach in my methodology, allowing qualitative methods to emerge in subsequent studies and integrating findings from both qualitative and quantitative analyses to address the research questions.

## 4.2 Stage 2: Generating a New Method

Stage 2 explores the effectiveness of existing pleasure-driven design theories in supporting designers in envisioning pleasurable experiences through IoT transformations, leading to the emergence of new design methods. This stage focuses on addressing sub-RQ2: "Which methods can support the creation of novel experiences through IoT transformations based on existing pleasure-driven design theories?" Three workshops were conducted, and a new method was generated at this stage. Workshops 1 and 2 are exploratory practices that assessed two existing pleasure-driven design frameworks by designing novel experiences for a representative IoT product – smartwatches. Workshop 3, which tested the newly developed method, will be introduced in Chapter 5. During this stage, I experienced lockdown due to the COVID-19 pandemic around the world. RCA campuses were closed, and in-person research activities were severely constrained. I had to return to my hometown, Qingdao, China, due to my mother's health issues and conducted my research remotely for 1 year and 8 months. As a result, both Workshops 1 and 2 were conducted online.

### 4.2.1 Workshop 1: Testing a Pleasure-Driven Design Framework with Experienced Design Practitioners

#### 4.2.1.1 Context

The findings of Survey 2 showed significant differences between the pleasurable experiences of smartwatches and wristwatches in terms of three types of pleasure and five psychological needs. To further test how established pleasure-driven theories influence the design of pleasurable experiences for IoT products in a practical setting, I conducted a workshop as an initial exploration. During Workshop 1, experienced design practitioners were introduced to Jordan's hierarchy of consumer needs (2002) (see Figure 2.6 and Table 2.5), aimed at exploring how this method guided their creation of innovative and pleasurable experiences for the chosen representative IoT product, smartwatches. The workshop targeted professionals with relevant working experience in experience design who were also smartwatch users. Their feedback was expected to reflect the effectiveness of the theories applied in practice. Moreover, their familiarity with smartwatches might encourage the generation of more innovative experiences. Prior to the workshop, ethics approval was obtained from the RCA Ethics Committee. The workshop was conducted during the COVID-19 pandemic, which posed constraints on participant recruitment. I reached out to my former colleagues and successfully recruited four experienced design practitioners who were also smartwatch users. They were working in four different cities in China at the time of the workshop and all had completed their master's degrees in the UK. Table 4.5 details participants' information and background. Despite the participants being known to me, efforts were made to minimise bias by focusing on a framework that was not developed by me. Additionally, a gender balance was ensured. This strategy prevented participants from feeling compelled to provide overly positive feedback or from hesitating to raise objections due to their relationship with me.

**Table 4.5 Descriptions of participants in Workshop 1.**

| Participant | Gender | Age | Nationality | City of Residence | Role | Working Experience |
|---|---|---|---|---|---|---|
| ***1*** | Female | 28 | China | Shenzhen | Product manager working on mobile game design | 3 years |
| ***2*** | Female | 27 | China | Shanghai | Interaction designer working on mobile application design | 2 years |
| ***3*** | Male | 32 | China | Beijing | Project manager working on cloud storage service design | 7 years |
| ***4*** | Male | 35 | China | Qingdao | Product designer working on domestic electronic product design | Over 10 years |

### 4.2.1.2 Method: Workshop

A workshop was selected as the appropriate method for this study because the results of Surveys 1 and 2 suggest that designers need to be engaged in design practices to test pleasure-driven theories. Workshops have proven to be an effective PD method for engaging participants in both academic and industrial contexts. They have served as a means for design researchers to obtain diverse feedback from communities, experts and stakeholders, (e.g., Kozubaev et al. (2019), Taylor et al. (2015), Vines et al. (2012)) and to generate new design opportunities around a topic or technology (e.g., Andersen and Wakkary (2019), Maxwell, Speed and Campbell (2015), Nissen et al.(2018)). Elsden et al. (2020) suggested that design workshops can act as a research tool, fostering a stronger sense of participation among participants and encompassing activities found in other qualitative methods such as interviews, focus groups, and ethnographic work. They also advised workshop organisers to carefully consider four key aspects: 1) the ambiguity of a workshop 2) the format of a workshop 3) the structure of a workshop and 4) the difficulty of gathering data in a workshop. Rosner et al. (2016) emphasised the importance of participant selection, facilitation and the design of workshop activities to ensure productive and meaningful outcomes. However, they also highlighted the challenges that can arise when conducting workshops within tight timeframes and at specific physical locations.

#### 4.2.1.3 Research Design

Jordan’s hierarchy for consumer needs (2002) was selected to be tested in Workshop 1 because Survey 2 revealed differences in three types of pleasure between smartwatches and wristwatches. This theory, focusing on consumer needs, was well-suited for experienced design practitioners who would likely be familiar with its principles. The workshop lasted for 3.5 hours, and it was conducted virtually using Zoom (a platform for online meetings) and Miro (a virtual whiteboard where users can paste stickers or write and draw their ideas) due to the COVID-19 pandemic. Before the workshop, participants signed a digital consent form (see Appendix E for details). I designed four activities for this workshop. Activities 1 and 2 served as warm-up and ice-breaking exercises for the participants. In Activity 1, they engaged in a brainstorming session to generate five keywords associated with smartwatches and five keywords associated with the IoT, which they noted down on Miro. In Activity 2, each participant engaged in a further brainstorming session to identify five objects related to smartwatches. During Activity 3, participants shared their most pleasurable experiences with their smartwatches. In Activity 4, the participants were divided into two groups. They were then tasked with creating a new feature relevant to the IoT aimed at delivering pleasurable experiences.

#### 4.2.1.4 Key Results

Figure 4.10 presents tasks completed by participants on Miro. Figure 4.11 depicts a participant sharing his smartwatch experience. In Activity 3, the four participants described their most pleasurable experiences using smartwatches. P1 enjoyed monitoring a data dashboard displaying steps, calorie consumption, and sleep hours, feeling greater control over her life and experiencing psycho-pleasure. P2 favoured activity badges, awarded for fitness goals, which she used to compete with a friend in Japan, fostering a sense of socio-pleasure through connectivity. P3 appreciated the Mindfulness app for relaxation at work and enjoyed the tactile satisfaction of the digital crown’s haptic feedback, blending physio- and psycho-pleasure. P4 found pleasure in using the digital crown for its precise control, a form of physio-pleasure. The concepts developed in Activity 4 are presented in Figure 4.12 and Figure 4.13.

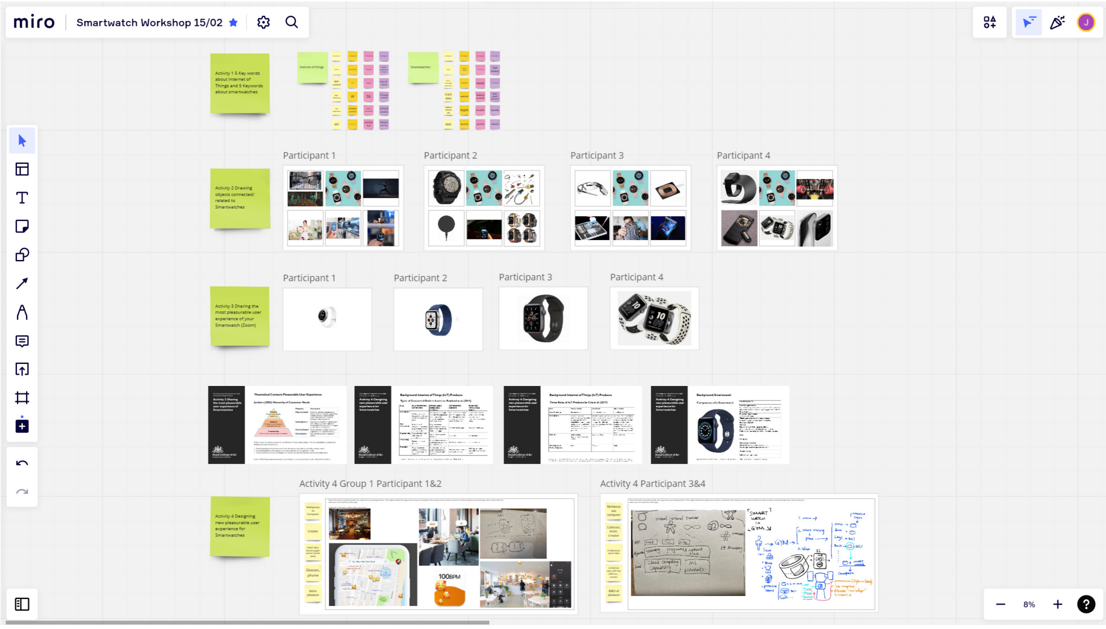


**Figure 4.10 Four actives in the workshop on Miro.**

**Figure 4.11 A participant sharing his pleasurable experiences with his smartwatch.**


**Figure 4.12 Group 1's concept – an emotion-evaluating application that links smartwatches, smartphones, and smart glasses to foster "social pleasure". The app uses health data from smartwatches and social media data from smartphones to assess nearby users' emotions, displaying emojis on devices to reflect these emotions. This facilitates communications by**

**allowing users to see the moods of others in places like coffee shops.**

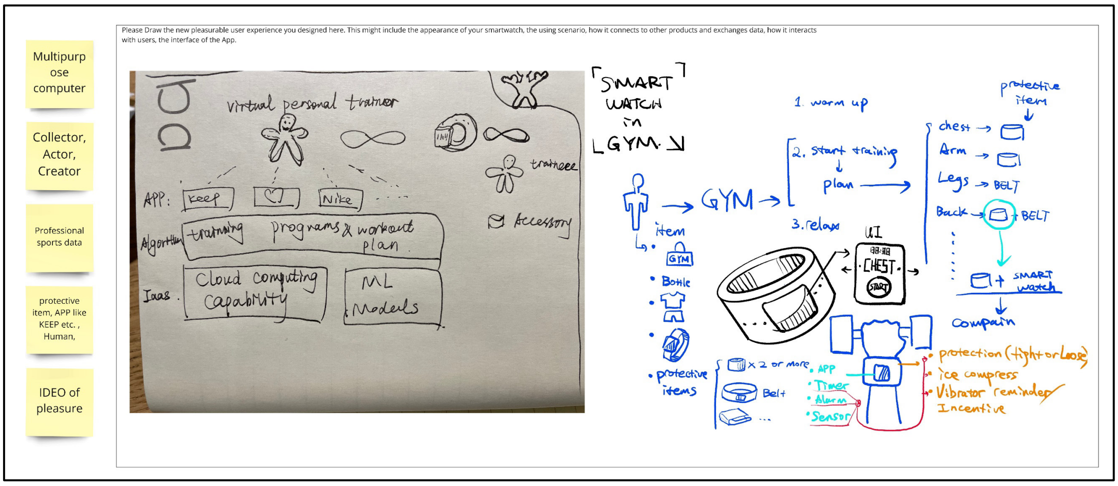


**Figure 4.13 Group 2's concept – a system transforming a smartwatch into a personal trainer, providing "ideo-pleasure" by helping users achieve their weightlifting goals during fitness training. Smart braces fitted on various body parts communicate with the smartwatch, which processes the data and guides users with sounds and vibrations to meet set goals.**

### 4.2.1.5 Reflections

#### Insights

Employing a type of pleasure in Jordan's theory (2002) as a design objective enables designers to focus on pleasurable experiences when designing interactions between users and smartwatches. Workshop 1 affirmed the relevance of existing pleasure-driven design theories for envisioning pleasurable experiences with IoT products and indicated the potential of exploring additional theories. Designers approached the IoT product not as an isolated entity, but as part of an ecosystem working collaboratively to enhance user experience, highlighting the influence of object interactions on shaping experiences. In Group 1's concept, participants tried to mediate human-to-human interactions by smartwatches. This approach might be inspired by Jordan's framework, which is unique among the four frameworks reviewed in section 2.2.5 for its inclusion of human interactions. This concept also showed how individuals can transition from interacting with connected objects to interacting through them, thereby enabling expressive communication (Helms, 2017). An IoT creativity-supporting tool for experience design should encourage designers to consider all types of interactions within an IoT system. Notably, Group 1's concept was focused on pleasure while Group 2's concept aimed at utility, which potentially improves training quality but does not necessarily increase pleasure. Future methods should encourage designers to prioritise hedonic quality over pragmatic quality as Hassenzahl et al. suggested (2013, 2015). The industry-based designers in this workshop developed the concepts targeted at the consumer IoT market, reflecting that pleasure-driven design principles from academia could potentially influence real-world design.

**Limitations**

Workshop 1 consisted of a small group of Chinese design professionals, a limitation primarily due to the COVID-19 pandemic which restricted the inclusion of a more diverse and larger group. All participants were Chinese and held master's degrees from the UK, hence their perspectives might not reflect a broader demographic. Additionally, the participants were former colleagues, which could potentially influence the results. Although the workshop focused on a framework not developed by me, aiming to minimise bias, the potential for their relationships with me to affect the outcomes cannot be entirely discounted.

#### 4.2.1.6 Summary of Findings

Workshop 1 demonstrated that Jordan's four types of pleasure (2002) are valuable for developing a new method for pleasure-driven design through IoT transformations, as evidenced by testing it with experienced design practitioners. This finding inspired me to integrate Jordan's theory into my newly developed framework (introduced in Section 5.1.1). Moreover, due to the impact of the COVID-19 pandemic, participant recruitment for Workshop 1 was limited, which motivated me to engage a more diverse group with varied ethnic backgrounds in the next workshop. The online workshop proved to be an effective research method during the pandemic, enabling the use of the same approach in the subsequent workshop during that period.

### 4.2.2 Workshop 2: Testing Two Pleasure-Driven Design Frameworks with Early-career Designers

#### 4.2.2.1 Context

During Workshop 1, I benefited from the contributions of experienced design practitioners who offered their ideas from a professional perspective. To further incorporate more innovative and reflective aspects and test additional pleasure-driven theories, Workshop 2 (Lin, Hall & Sommer, 2022) engaged early-career designers. It focused on continuing the exploration of how these theories support designers in creating novel and pleasurable experiences for the representative IoT product, namely smartwatches. This study has been published and presented as a peer-reviewed paper (Lin, Hall & Sommer, 2022) at the DRS2022 conference (The Design Society, 2023). DRS is a renowned international conference in the field of design research that brings together academics, researchers and practitioners to share and advance knowledge on design theory, methodology and practice across diverse design disciplines and applications. Workshop 2 involved 25 master's students (11 females and 14 males) enrolled in the Innovation Design Engineering *(IDE)* programme at the RCA. This group of students was selected for their diverse and high-quality educational and professional backgrounds, their training in innovative physical computing design projects in the IDE programme and their engineering knowledge of technologies, which is unique at the RCA. Ethical approval was obtained from the RCA Ethics Committee along with Workshop 1. Participants were recruited via an invitation email sent to the group by IDE staff. The workshop was conducted online through Zoom and Miro, as all the students at RCA were in distance learning mode due to the COVID-19 pandemic. During the workshop, participants designed novel experiences through smartwatches and presented these experiences by role-playing.

#### 4.2.2.2 Research Design

Similar to Workshop 1, this study also adopted the workshop method for its design. Workshop 2 lasted for 2.5 hours and comprised two activities. Before starting design activities, I introduced IoT and two pleasure-driven theories to the participants through a presentation. These theories, Jordan's hierarchy of consumer needs (2002) (see Figure 2.6) and Hassenzahl's three-level hierarchy of goals (2010) (see Figure 2.9), were selected for participants because they were applied in designing Surveys 1 and 2 which proved valuable for further testing in design practices. Then the participants engaged in two design activities. In Activity 1, participants were tasked with designing a new experience for smartwatches, using one of the introduced theories as a guide. I separated participants into five groups using the "breakout rooms" function on Zoom and assigned a virtual whiteboard to each group on Miro, which allows participants to add stickers, write notes, paste images and sketch ideas. Working in groups facilitates the pooling of knowledge and inspiration among these early-career designers, which potentially leads to more creative concepts. The participants analysed the IoT product (smartwatch) and the theory they chose, recorded their brainstormed ideas with stickers and doodles and visually presented their final idea with sketches and images on the whiteboard.

In Activity 2, the participants were required to present how users perceive the experiences they had designed by role-playing (Simsarian, 2003; Girard & Johnson, 2011), which is a method that can reimagine users' relationship with objects by encouraging humans to act from the perspective of objects (Chang et al., 2017). The participants remained in their previous groups and had 15 minutes to discuss and create their narratives. Subsequently, participants demonstrated how someone would use a smartwatch to gain the designed experience in front of their cameras on Zoom. Through role-playing, designers assumed the roles of both the user and the IoT product, embodying the experiences that users would encounter in actual usage scenarios.

#### 4.2.2.3 Key Results

In the process of designing experiences for smartwatches, the five groups undertook similar steps. They started with an analysis of the framework they chose and the sensors embedded in a smartwatch, and then employed brainstorming to identify factors potentially influenced by the smartwatches in their selected scenarios. A comparison of concepts from the three types of interactions and the pleasurable elements is shown in Table 4.6. Details of these concepts and participants' role-playing scenarios are presented in Figures 4.14 to 4.23. Groups 1 and 5 selected Jordan's theory to underpin their design activities, whereas the remaining three groups applied Hassenzahl's theory. The concepts shared several features: all were derived from an app, data-driven and included a voice assistant which allows users to interact with their smartwatches through voice commands. Notably, only the concepts from Groups 1 and 5 considered interactions between objects and interactions between humans mediated by objects. The other three concepts focused solely on interactions between humans and objects.

**Table 4.6 Comparison of the concepts of five groups in Workshop 2.**

| | **Group 1** | **Group 2** | **Group 3** | **Group 4** | **Group 5** |
|---|---|---|---|---|---|
| **Applied theory** | Jordan's (2003) | Hassenzahl's (2010) | Hassenzahl's (2010) | Hassenzahl's (2010) | Jordan's (2003) |
| **Design concept** | A social app | A health monitoring app | A travelling app | A fitness app | A navigation app |
| **Interactions between humans and objects** | √ | √ | √ | √ | √ |
| **Interactions between humans** | √ | x | x | x | √ |
| **Interactions between objects** | √ | x | x | x | √ |

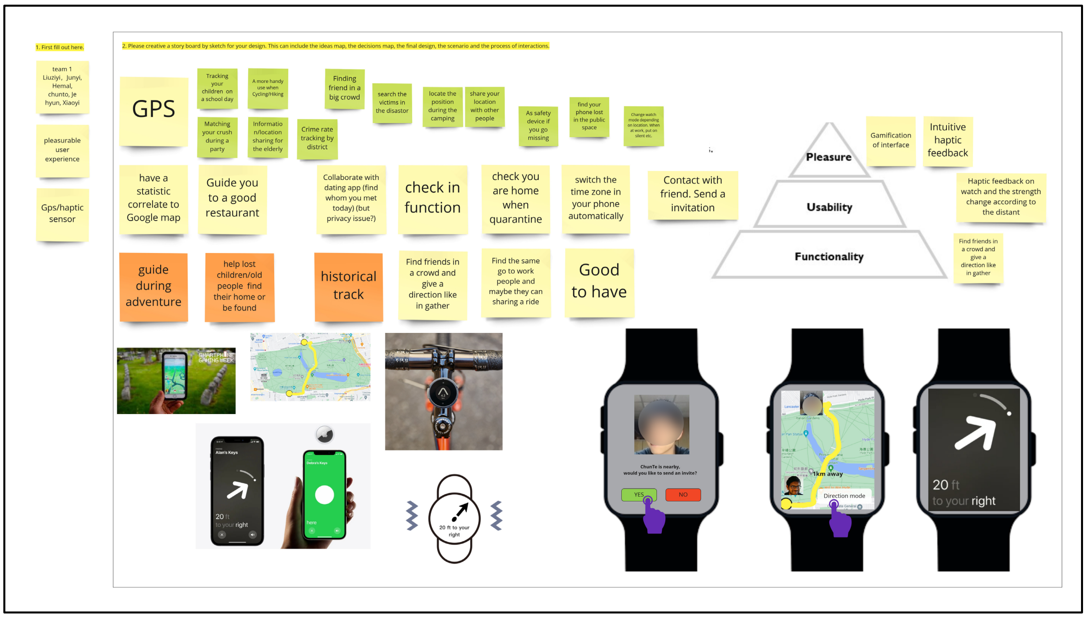


Figure 4.14 Group 1's experience concept – Utilising Jordan's framework as a guideline, they designed a smartwatch experience that facilitates local social interactions. Users can share their GPS location and track the location of their friends. The smartwatch calculates the distance between users and alerts them when a friend is nearby. If the user wishes to meet, the smartwatch provides navigation assistance.

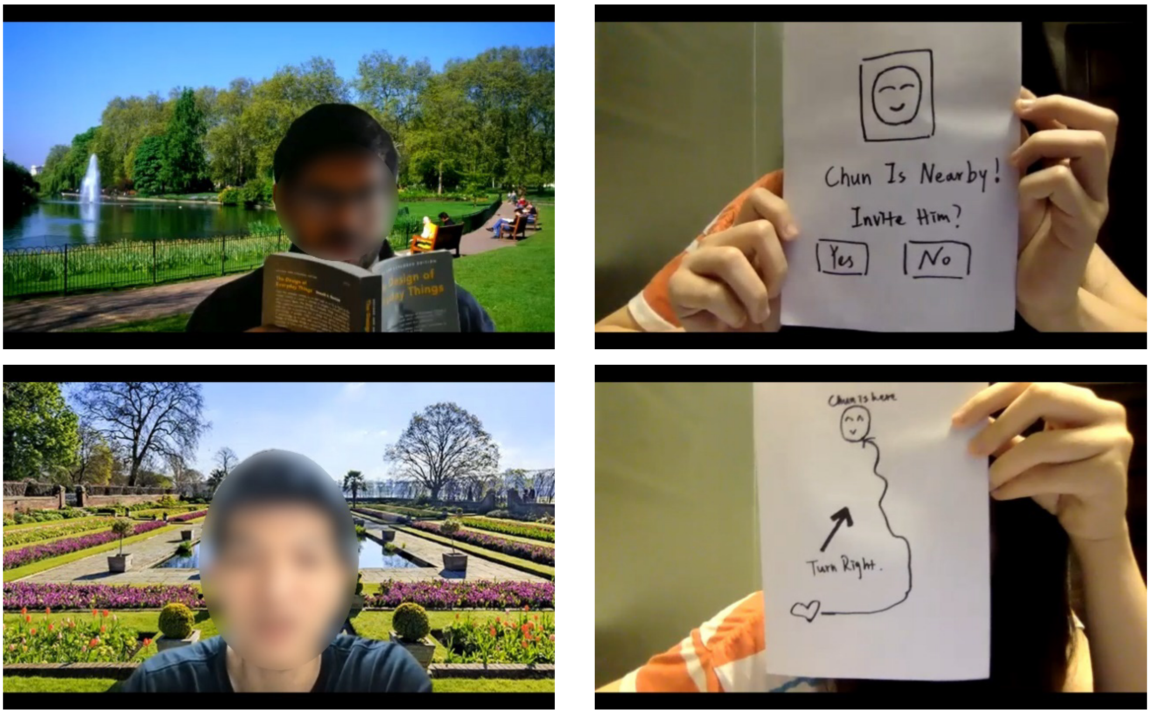


Figure 4.15 Group 1's role-playing – They presented a scenario in which a smartwatch user reading in Hyde Park after submitting his coursework used his smartwatch to identify his friend who was also sitting in the same park. The smartwatch user sent an invitation to his friend, and his friend accepted it. They went for lunch together.

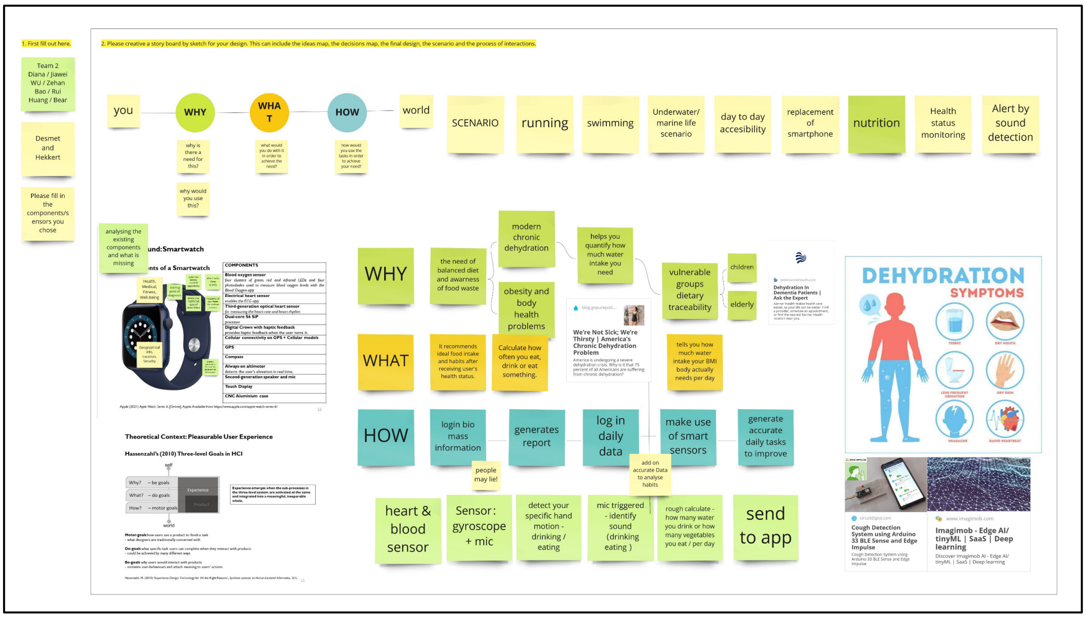


**Figure 4.16 Group 2's experience concept – Employing Hassenzahl's framework, they designed an experience for smartwatches aimed at helping users manage their dietary nutrition. The new feature uses the gyroscope to monitor the user's arm movements during eating and a voice sensor to identify food types based on the sounds produced by the user's throat and mouth. Utilising machine learning, the application estimates the user's nutritional intake from the collected data and provides dietary suggestions through a virtual assistant.**

**Figure 4.17 Group 2's role-playing – They presented a scenario of a smartwatch user eating a croissant and his smartwatch detecting that he was taking in too much sugar. The virtual assistant notified the user and suggested that he should eat a banana after his meal. The user**

**followed his smartwatch's instructions to modify his diet, and the virtual assistant praised the user with a voice message.**

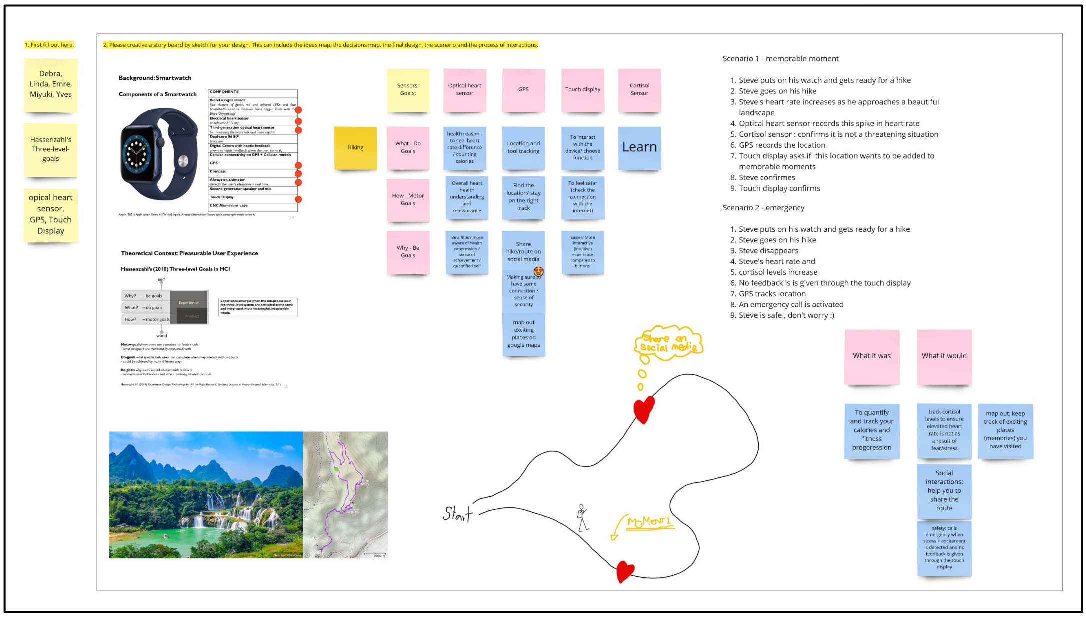


**Figure 4.18 Group 3's experience concept – Utilising Hassenzahl's framework, they designed an experience that enables users to record memorable locations visited during hikes or walks, facilitating the convenience of revisiting these places. They integrated a cortisol sensor into the Apple Watch to analyse how moments are converted into memories. The sensor assesses cortisol levels in the body, allowing the smartwatch to infer the user's mood.**


**Figure 4.19 Group 3's role-playing – They presented a smartwatch user hiking in favourable**

weather with the heart, GPS, and cortisol sensors active. The smartwatch identified excitement when the user encountered a scenic view, adding this memorable moment to the map. When the user fell down a steep hill, the smartwatch inferred danger from the spike in heart rate and cortisol levels and activated an emergency call to save the user.

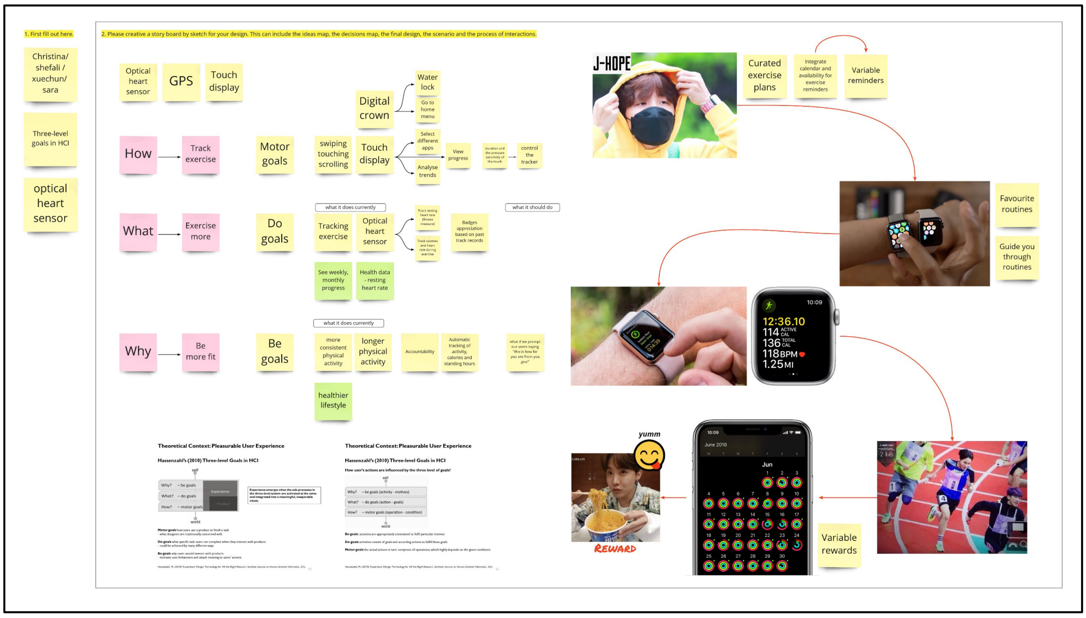


**Figure 4.20 Group 4's experience concept – Utilising Hassenzahl's framework, they redesigned the exercise experience with the Apple Watch. Noting that the existing exercise function had become less effective and was difficult to pause or cancel, two long-term users in the group improved this feature. They integrated the calendar to identify break times, during which the smartwatch prompts users to exercise and suggests appropriate routines.**

**Figure 4.21 Group 4's role-playing – They presented a scenario of a smartwatch reminding the user to exercise by attracting the user's attention with a voice assistant and recommending a routine. The user accepted the recommendation and performed exercises following the instructions. The voice assistant showed the user her heart rate and her exercises' effectiveness and helped her to set up a reminder for the next exercise on her calendar.**

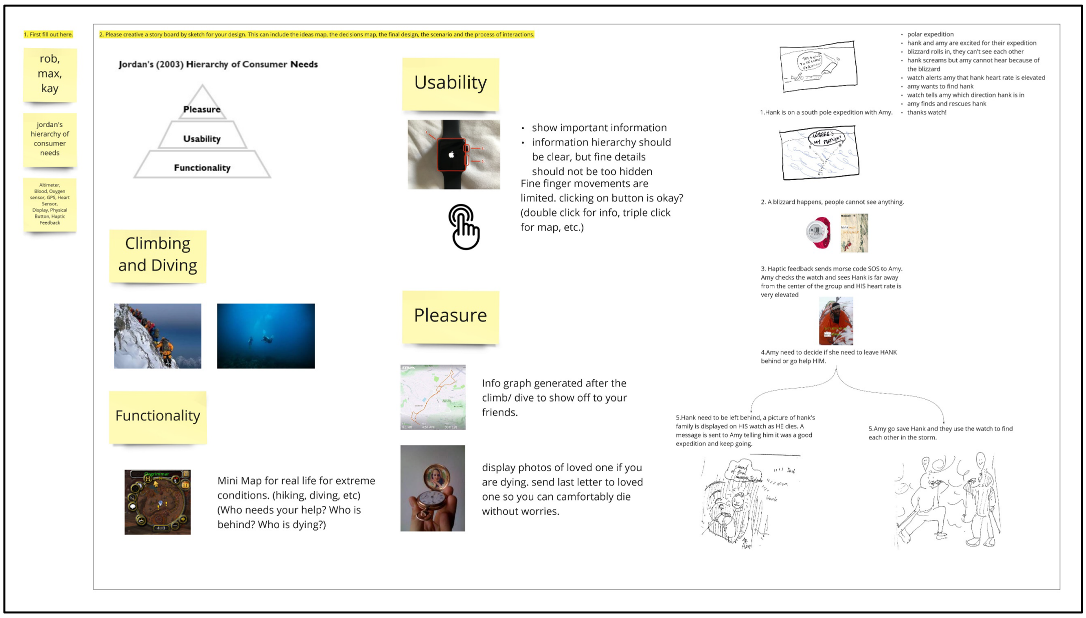


**Figure 4.22 Group 5's experience concept – Applying Jordan's framework, they designed a smartwatch experience in extreme scenarios such as climbing and expeditions. They determined that Bluetooth, radio, Wi-Fi, GPS, or a combination of them could be used to locate users, particularly in low-visibility conditions. The smartwatch features a mini-map to prevent**

**users from getting lost. Additionally, they developed a function for life-threatening situations in extreme environments, allowing users to leave a message for their family accompanied by a photo, which could offer comfort during difficult times.**

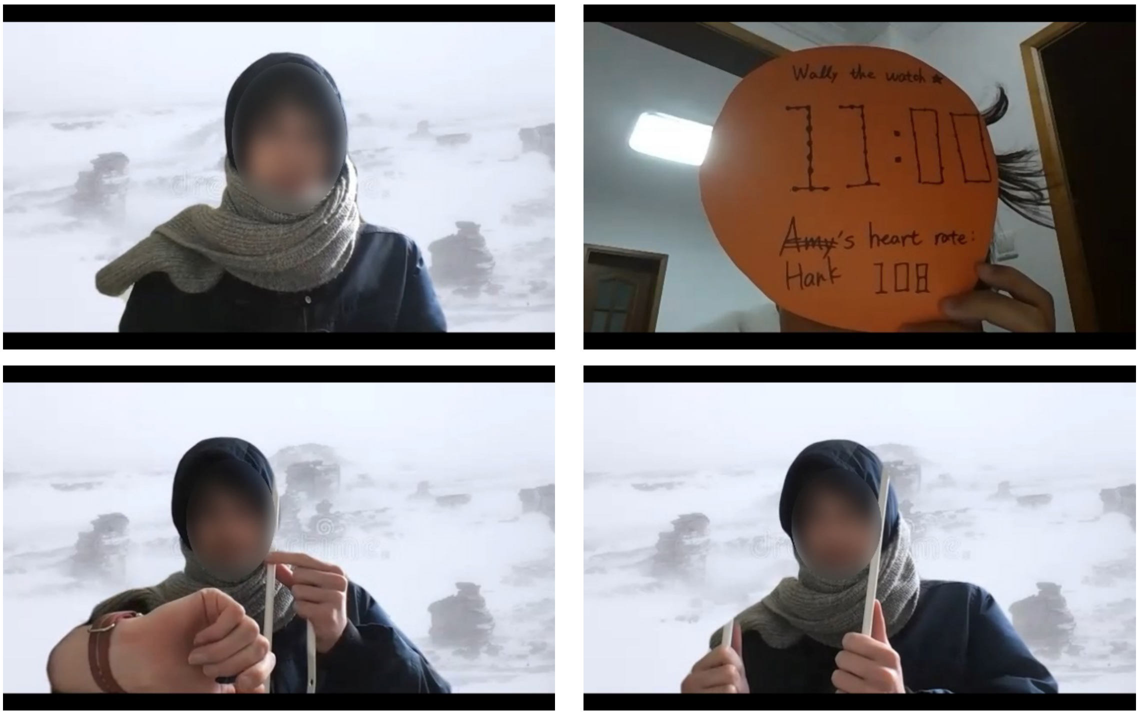


**Figure 4.23 Group 5's role-playing – they presented a scenario of two explorers, Amy and Hank, encountering a heavy blizzard. Hank got lost and was in danger. Amy received the information on her smartwatch, and she found Hank by relying on the Morse code his smartwatch sent to hers.**

## 4.2.2.4 Reflections

### Insights

The outcomes of Workshops 1 and 2 highlight essential elements that a new method supporting pleasure-driven design through IoT transformations should incorporate but are missing in existing theories. These workshops suggested that existing pleasure-driven theories, such as those proposed by Jordan (2002) and Hassenzahl (2010), provide clear design objectives for designers. However, in Workshop 2, only two groups developed ideas that involved all three types of interactions within an IoT system, while the remaining three groups focused solely on the interactions between humans and objects. Interestingly, Group 1's concepts, which involved human interactions mediated by objects, drew on the "socio-pleasure" aspect of Jordan's theory. This is similar to the emotion-evaluating concept in Workshop 1. Although Hassenzahl's theory includes the psychological need for relatedness which is highly relevant to interactions between humans, it was not applied by any group in this context. This oversight suggests that even designers with considerable knowledge and training in physical computing may neglect certain types of interactions when applying these theories to IoT scenarios. The novel interactions that emerge within an IoT system offer designers opportunities for shaping experiences (Wakkary et al., 2017, 2018), which should be considered concurrently with the application of pleasure-driven theories.

To support designers in effectively envisioning experiences in an IoT scenario, these existing pleasure-driven theories should be integrated with the unique features of IoT products, such as their data collection, agency and roles and interactions. This integration will enable designers not only to focus on pleasure-driven design but also to leverage the full capabilities of IoT. As extensions of Surveys 1 and 2, Workshops 1 and 2 explored how IoT transformations can shape pleasurable experiences in practice. The increased agency provided by IoT transformations mediates three types of interactions, thereby influencing pleasurable experiences (as illustrated in Figure 4.24). Reflecting on Sterling's (2005) notions of spimes and wranglers, the transformation of analogue products into IoT products changes the human-object relationship through the sensemaking of collected data. Smartwatches, as an example of IoT products, no longer focus on the utilitarian function of telling time but now include extensive features based on data collection, thus exemplifying this shift. The concepts developed in Workshops 1 and 2, which focused on the reflective level of experiences, demonstrate how this transition enables designers to shift their focus from pragmatic to hedonic qualities of a product.

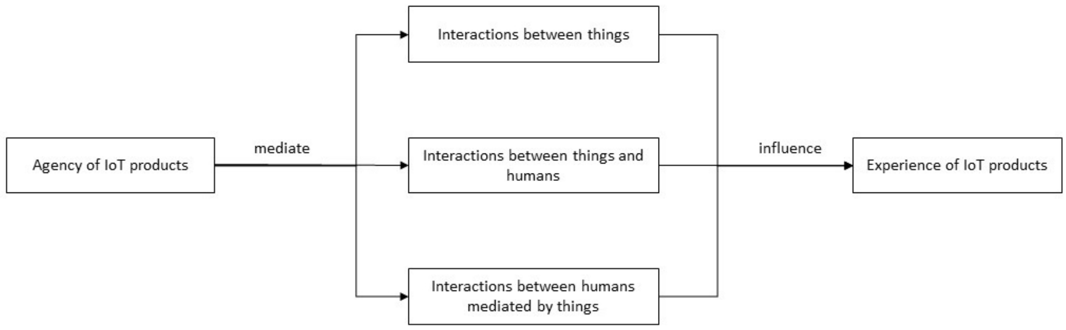


**Figure 4.24 The relationship between agency, interactions and experience in an IoT system.**

**Limitations**

The participants of Workshop 2 were early-career designers from multidisciplinary backgrounds, pursuing double master's degrees in IDE and holding bachelor's degrees. They represent the attitudes of a group of designers with a certain level of knowledge in engineering design, which might not include the broader range of disciplines involved in IoT, such as experience design, UI design and service design. Although their working experience is less extensive than that of the participants in Workshop 1, their approaches tend to be more exploratory and innovative. Combining their perspectives with those from Workshop 1 could balance the commercial and innovative perspectives.

### 4.2.2.5 Summary of Findings

Workshop 2 demonstrated that Hassenzahl's six psychological needs (2015; 2021) are valuable for developing a new method for pleasure-driven design through IoT transformations, motivating me to incorporate this theory into my novel framework. Additionally, the findings highlighted the importance of considering agency and multiple interactions – factors that were not emphasised when using IoT transformations as a tool for shaping pleasurable experiences in the workshop. These elements missing from existing pleasure-driven design frameworks can be integral to a new framework. The findings of Workshops 1 and 2 collectively revealed the need to connect established pleasure-driven design theories and unique features of IoT transformations through a new framework. Thus, I developed a novel framework that integrates the theories tested in Surveys 1 and 2 and Workshops 1 and 2, which will be presented in the next chapter.

# 5. *The IoTT for PLEX Framework* Design Practices

The exploratory practices in the previous chapter revealed the potential influence of IoT transformations on pleasurable experiences and identified the deficiencies in existing pleasure-driven design theories when applied within the IoT context. This chapter presents the new method – *the **IoT** **T**ransformation for **Pl**easurable **Ex**periences (IoTT for PLEX) Framework* – developed based on these findings, along with three practices that applied this novel framework. Figure 5.1 shows the placement of these practices within the entire research.

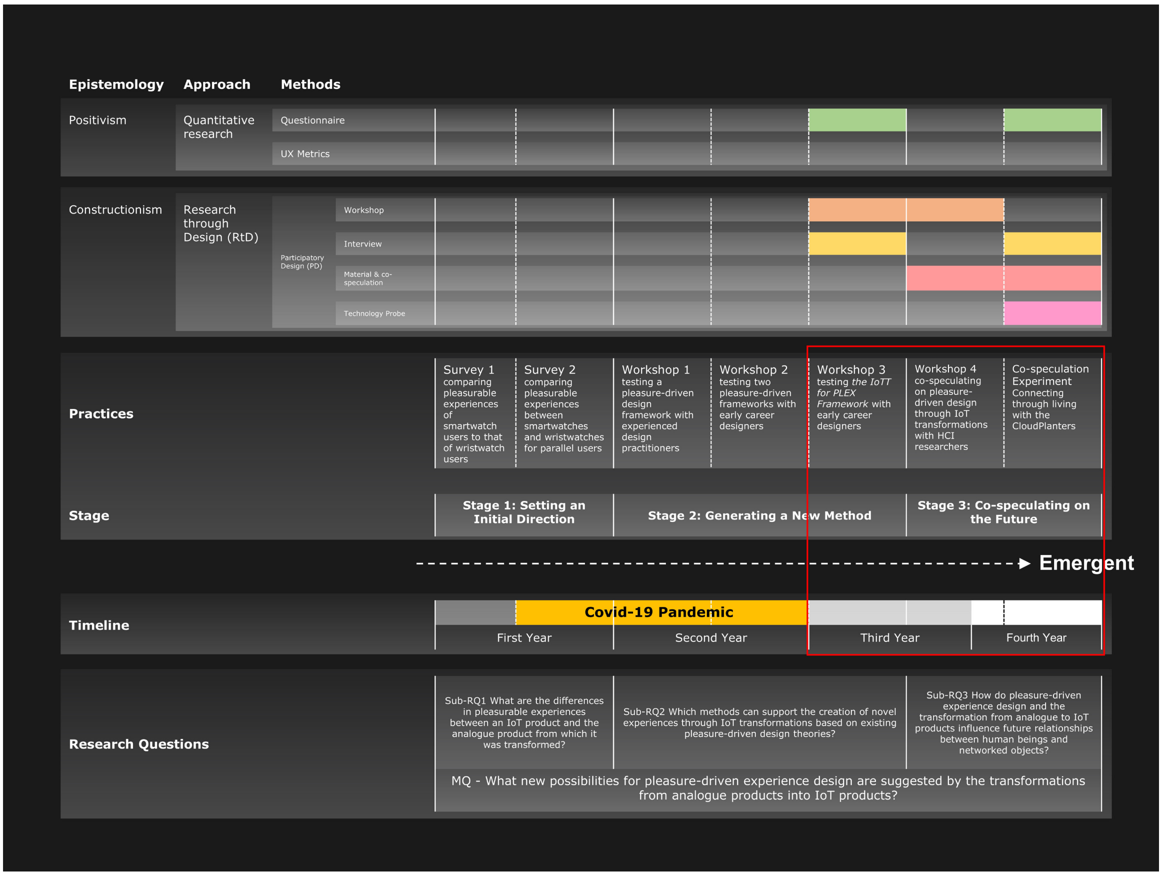


**Figure 5.1 The placement of the studies presented in Chapter 5 within the entire research (corresponding studies highlighted in the red rectangle).**

## 5.1 Stage 2: Generating a New Method

After conducting Workshops 1 and 2 in Stage 2, I developed *the IoTT for PLEX Framework* based on these findings. This framework addresses sub-RQ2: "Which methods can support the creation of novel experiences through IoT transformations based on existing pleasure-driven design theories?" Workshop 3 subsequently tested how the novel framework supports designers in envisioning pleasurable experiences through IoT transformations in practice.

### 5.1.1 Developing *the IoTT for PLEX Framework*

The aim of *the **IoT** **T**ransformation for **Pl**easurable **E**xperiences (IoTT for PLEX) Framework* is to support designers in envisioning pleasurable experiences by transforming analogue products into IoT products, drawing on pleasure-driven theories. The framework includes three steps: **1. Outlining a pleasurable experience pattern**; **2. Adding IoT features to the product**; and **3. Designing interactions within the IoT system**. An overview of *the IoTT for PLEX* is presented in Figure 5.2. The inspiration for this framework comes from Hassenzahl and Desmet's possibility-driven design (2012) and Hassenzahl et al.'s experience design method (2013), both of which emphasise creating new possibilities for happiness rather than solely tackling negative experiences. As a result, my framework encourages designers to explore innovative concepts for delivering pleasurable experiences through IoT transformations, shifting the focus from problem-solving to pleasure-driven ideation.

Hassenzahl et al. (2013:p.24) introduced the approach of designing pleasurable experiences based on an experience pattern: "it [experience-design] starts with an individual experience of feeling close to significant others and the suggestion to distil the essence of such a positive and meaningful experience into a pattern. The pattern allows to transfer the experience into a new context […] and to design a novel experience based on the knowledge about a happy moment captured by the pattern". My framework adopts this approach and prioritises different types of pleasure and psychological needs over the functions and interactions of IoT products, guiding designers to summarise a pleasurable experience pattern and recreate it through the transformation from an analogue to an IoT product. The primary design outcome from utilising this framework is not merely the creation of a new IoT product but, more importantly, the generation of novel pleasurable experiences.

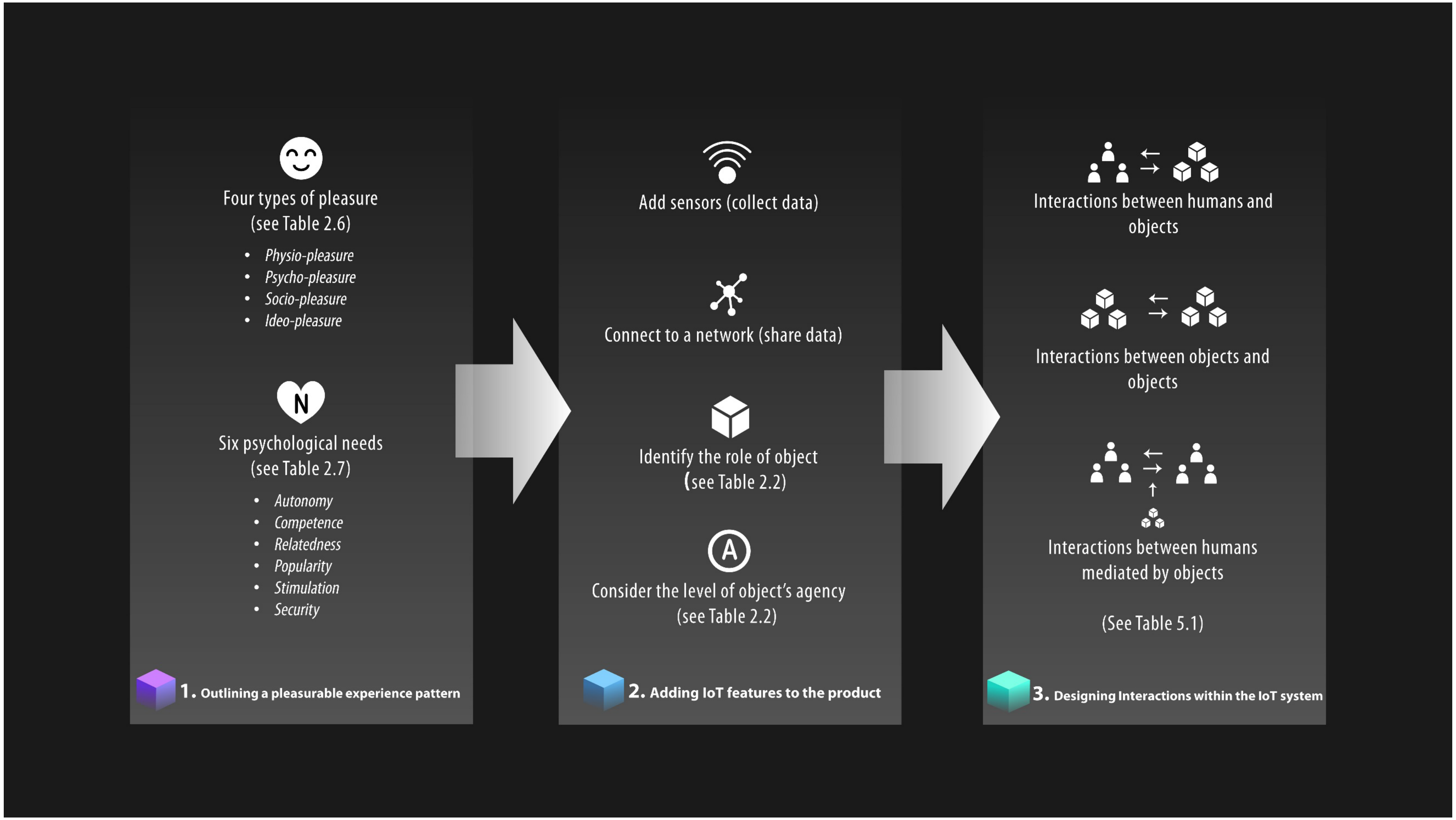


**Figure 5.2** ***The IoT Transformation for Pleasurable Experiences (IoTT for PLEX) Framework.***

*The IoTT for PLEX Framework* comprises three detailed steps, as follows:

**Step 1: Outlining a pleasurable experience pattern.** Designers are required to select a specific type of pleasurable experience to design for before starting the design process. A prior study (Yoon et al., 2021) has shown that each type of pleasurable experience varies in terms of the conditions required to elicit it, the emotions it evokes, and its impact on people's behaviours. Jordan (2002) proposed that a pleasurable product experience involves at least one of four types of pleasure, while Hassenzahl et al. (2010; 2013, 2015) argued that when users perceive pleasurable experiences from a product, at least one psychological need is fulfilled. For the framework, I adopted the four types of pleasure based on Tiger (2000) and Jordan (2002), as well as the six psychological needs based on Hassenzahl et al. (2010; 2015) and Sheldon et al. (2001). The meanings of the four types of pleasures and six psychological needs are detailed in Table 2.5 in *Section 2.2.5.1* and Table 2.6 in *Section 2.2.5.4*. The selection of these types of pleasure and psychological needs was informed by exploratory practices introduced in Chapter 4 that highlighted how they are influenced differently by analogue products and IoT products. In this step, designers need to outline a specific pleasurable experience pattern aimed at eliciting a type of pleasure or fulfilling a psychological need, drawing from their personal experiences. In the two subsequent steps, they use IoT transformations as materials to recreate and deliver these patterns.

**Step 2: Adding IoT features to the product.** This step involves several key considerations regarding IoT features for designers. They need to consider the integration of sensors for data collection, establishing connections to a network for data sharing, identifying the role of their designed object within the IoT system, and carefully assessing the level of object agency. IoT transformations shift the focus of experience design to the sensemaking of data. Building upon the pleasurable experience patterns outlined in Step 1, designers should have a clear purpose in collecting data that aligns with their design objectives. The categorisations of IoT products discussed in the literature review suggest that different roles of IoT products possess various levels of agency and designers need to re-evaluate the human-nonhuman relationships within IoT systems. Cila et al.'s taxonomy (2017) (presented in Table 2.2) was adopted into this framework as it classifies IoT products' roles based on their agency, and Workshops 1 and 2 revealed that the agency of an object is an important element for shaping IoT experiences. This taxonomy can guide designers in understanding and distributing the agency of IoT products to realise the experience pattern they summarised in Step 1.

**Step 3: Designing interactions within the IoT system.** This step is a critical aspect where designers strategically deliver the outlined experiences to users through three general types of interactions: interactions between humans and objects, interactions between objects and objects, and interactions between humans mediated by objects. Table 5.1 provides a comprehensive summary of sixteen specific types of interactions within an IoT network, helping designers explore various possibilities based on output and input considerations. The table aims to facilitate a better understanding of the active and passive relationships between actors within an interaction, enabling designers to create meaningful experiences by building up an interaction network. Building on Hassenzahl et al.'s work (2015), which highlighted the relevance of psychological needs fulfilment to hedonic quality (though not strongly linked to pragmatic quality), designers should move beyond the interactions of a product's basic functions. Instead, they must create additional interactions that facilitate further activities, fostering pleasurable experiences for users when utilising IoT features.

**Table 5.1 16 types of interactions associated with an IoT network involving object(s) and/or human(s).**

| **Output/Input** | ***Single Object (in)*** | ***Single Human (in)*** | ***Multiple Objects (in)*** | ***Multiple Humans (in)*** |
|---|---|---|---|---|
| ***Single Object (out)*** | Object-to-object interactions | Human-to-object interactions | Objects-to-object interactions | Humans-to-object interactions |
| ***Single Human (out)*** | Object-to-human interactions | Human-to-human interactions | Objects-to-human interactions | Humans-to-human interactions |
| ***Multiple Objects (out)*** | Object-to-objects interactions | Human-to-objects interactions | Objects-to-objects interactions | Humans-to-objects interactions |
| ***Multiple Humans (out)*** | Object-to-humans interactions | Human-to-humans interactions | Objects-to-humans interactions | Humans-to-human interactions |

### 5.1.1.1 Positioning *the IoTT for PLEX Framework*

Peters et al. (2018) argued that despite extensive research on designing pleasurable and meaningful experiences in HCI from 2013 to 2018, there was a dearth of studies establishing a clear actionable connection between these theories and practical application. *The IoTT for PLEX Framework* attempts to bridge this gap. It stands apart from existing experience design frameworks and

IoT ideation frameworks due to its distinctive features. While many existing experience design frameworks (Jordan, 2002; Norman, 2005b; Desmet & Hekkert, 2007; Hassenzahl, 2010; Desmet & Pohlmeyer, 2013) offer insights on how to design a comprehensive pleasurable experience, *the IoTT for PLEX Framework* sets itself apart by focusing on eliciting specific types of pleasure or fulfilling particular psychological needs with the use of IoT technology. Nonetheless, *the IoTT for PLEX Framework* draws inspiration from these experience design frameworks and incorporates concepts from psychology, such as the four types of pleasure and six psychological needs, to facilitate designers' understanding of experiences. This combination of ideas from both disciplines enriches the framework and encourages designers to create pleasurable and meaningful experiences using IoT transformations.

As discussed in *Section 2.3.2*, the majority of IoT creativity-supporting tools are primarily designed to generate novel ideas for IoT products. However, *the IoTT for PLEX Framework* aims to produce innovative ideas focused on pleasurable experiences as its outcome. While the transformation from analogue to IoT products serves as a crucial element within the framework, its primary purpose is to deliver pleasurable experiences. Consequently, *the IoTT for PLEX Framework* is best described as a dedicated experience design tool, distinct from comprehensive product development tools like Vitali and Arquilla's MappingTheIoT Toolkit (2016). **The target audience for this framework comprises experience designers, product designers and interaction designers seeking to envision novel experiences for IoT products, and design and HCI researchers who want to use this framework as a research tool.** *The IoTT for PLEX Framework* was inspired by Lilidots (De Roeck et al., 2012) and Tiles IoT Toolkit (Mora, Gianni & Divitini, 2017) for the adoption of an open-ended approach, prioritising creativity over technical considerations, as designers and design researchers within the target audience may not possess extensive technological knowledge. Additionally, by adopting the strategy of quickly delivering knowledge from Knowcards (Aspiala, 2014) and The IoT Deck (Chen, Liang & Chiang, 2011), *the IoTT for PLEX Framework* helps designers swiftly grasp the requisite knowledge for design activities, including the four types of pleasure and six psychological needs.

### 5.1.2 Workshop 3: Conducting Pleasure-Driven Design through IoT Transformations by Applying *the IoTT for PLEX Framework*

#### 5.1.2.1 Context

Workshop 3 was conducted with a cohort of early-career designers (distinct from the cohort in Workshop 2) to test how *the IoTT for PLEX Framework* supports them in envisioning innovative pleasurable experiences through IoT transformations. Following the completion of the workshop, I gathered feedback from the participants through a combination of questionnaires and interviews. These data sources enabled me to conduct both quantitative and qualitative analyses of the participants' ideation and feedback. After obtaining ethical approval from the RCA Ethics Committee, I recruited early-career designers from postgraduate students at the School of Design, RCA, through an invitation email sent by the Administration Office. These students were targeted because they possessed professional-level design qualifications, had diverse cultural, educational and professional backgrounds and were open to new methods. Some had prior experience in the design industry. Initially, 31 potential participants expressed their interest by filling out a registration form via Google Forms, providing information about their backgrounds and motivations for participation. The final selection of 15 participants (8 males and 7 females), referred to as P1 to P15 in later discussions, was based on their responses to the registration form. Preference was given to designers with strong motivation and experience related to IoT projects. These participants, aged between 22 and 35, were from four different master's programmes and a PhD/MPhil programme in the School of Design at the RCA. They held bachelor's degrees in design-related fields from universities in four countries (China, India, the UK and the USA). A significant portion, 80% (n = 12), had prior experience working on IoT projects. The preference for participants with previous experience was due to their being better equipped to provide feedback on an IoT creativity-supporting tool, and they did not need to learn the basic concepts of IoT from scratch during the workshop. The participants came from various geographic regions, with some having English as their second language: China (6), Hong Kong (1), India (2), the UK (2), the UK and Japan (1) and the USA (1) (two participants chose not to disclose their geographic origin).

#### 5.1.2.2 Method: Interview

The methods involved in this study include a workshop and interviews. Interviews have commonly been used in IoT-related design research for collecting participants' feedback and interpreting usage patterns. In Wakkary et al.'s (2018) study, philosophers who participated were interviewed at the midpoint and the end of their experience with the tilting bowl. These interviews allowed the philosophers to contribute their speculations about the human-object relationship from a philosophical perspective. Similarly, in Giaccardi et al.'s study (2016a, 2016b), participants were interviewed to reflect on their interactions with mugs, kettles and fridges in the kitchen, providing explanations for the data collected by digital sensors. In general, interviews provide researchers with the opportunity to directly engage with participants and collect primary data on their experiences, opinions, attitudes and perceptions (Bryman, 2012:p.469). By structuring the interview, researchers can guide the discussion and address specific points of interest. At the same time, the interviewee is given an open space to articulate their views.

#### 5.1.2.3 Research Design

To guide the creative activities, I prepared six design themes: jug blender for stimulation, lamp for competence, rubbish bin for ideo-pleasure, teapot for relatedness, wardrobe for autonomy and washing machine for socio-pleasure. The selection of these themes was inspired by the strategy of employing everyday object augmentation in IoT design, as proposed by Kuniavsky (2010). He argued that working with familiar objects and adding IoT features could facilitate the learning of key attributes and everyday affordances, enabling designers to work on pre-existing experience patterns. The establishment of design themes was also influenced by previous studies that discussed mundane domestic products as typical examples of IoT transformations and how they mediate experiences (e.g., smart coffee machine (Pschetz et al., 2017), smart hair dryer (Pschetz, Pothong & Speed, 2019), smart kettle (Lindley, Coulton & Cooper, 2017) and smart fridge (Fantini van Ditmar, 2016)). My final selection of each design theme was based on the following reasons:

- **Jug blender for stimulation:** The jug blender is linked to nutritional balance and a healthy lifestyle, suggesting its potential to deliver experiences that meet users' psychological needs for stimulation.

- **Lamp for competence:** Lamps are used in multiple scenarios, and the variation in light colour can alter the ambience, influencing users' emotional experiences. Proper lighting supports various tasks and activities, potentially fulfilling the psychological need for competence.
- **Rubbish bin for ideo-pleasure:** The functionality of a rubbish bin is naturally tied to recycling and sustainability, an ideology pursued by many, suggesting its potential to elicit ideo-pleasure.
- **Teapot for relatedness:** Partaking in tea drinking is a prevalent leisure activity across diverse cultures, often involving social interactions. This suggests the teapot's potential to address users' psychological needs for relatedness.
- **Wardrobe for autonomy:** Wardrobes are simple, form-following-function products that typically lack electronic components, requiring users to perform all actions independently. They also present private property in the bedroom. Consequently, they hold the potential to fulfil users' psychological needs for autonomy.
- **Washing machine for socio-pleasure:** Washing machines inherently possess the attribute of shared usage, whether within households among family members or in public laundry rooms for communal use by a broader community.

Prior to participating in the three-hour workshop, the participants completed digital consent forms (see Appendix I for details), which were then sent back to the organisers. The workshop began with my presentation, which introduced *the IoTT for PLEX Framework* to help participants understand existing pleasure-driven design theories. Then, 15 participants were divided into groups by drawing lots and completed design tasks 1 and 2 in the workshop. Tasks 1 and 2 were printed on A3 and A2 sheets respectively (see Figure 5.3). Each task sheet contained details of the analogue product, the intended pleasure or psychological need to be fulfilled, and the tasks that needed completion. In Task 1, each group summarised an experience pattern to elicit the specified pleasure or fulfil the psychological need provided on the task sheet. Then they brainstormed ways to transform the product into an IoT form to achieve the experience pattern. In Task 2, participants finalised their ideas, confirming the final sensors embedded in their products and the data they collected. They also created a final sketch of the transformed product and a storyboard to depict how users would perceive experience when interacting with the product. Figure 5.4 illustrates the workshop in progress, and more images recorded from the workshop can be found in

Appendix J. Following the workshop, an online questionnaire (see Appendix L for details) was sent via email to all participants to gather feedback on the framework and the workshop, with responses received from all participants. Among the respondents, three participants provided valuable insights in the open-ended question section. I conducted one-on-one interviews with these participants to further discuss the framework and their understanding of the relationship between pleasurable experiences and IoT products (see Appendix N for specific interview questions). The workshop structure is presented in Figure 5.5.

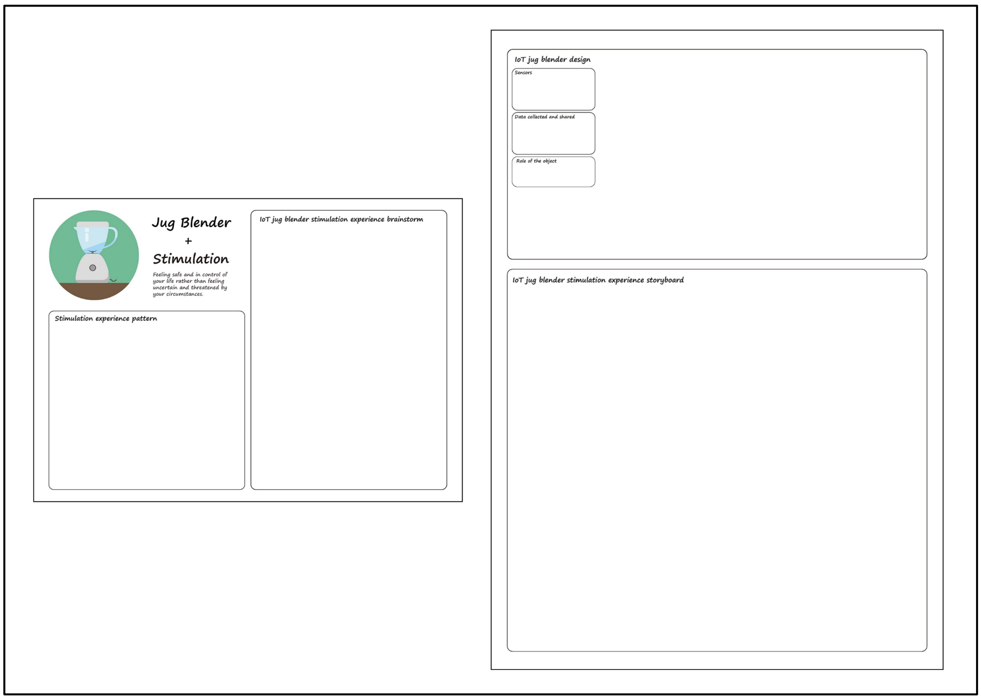


**Figure 5.3 Task sheets 1 and 2 for Workshop3.**

**Figure 5.4 Workshop 3 in progress.**

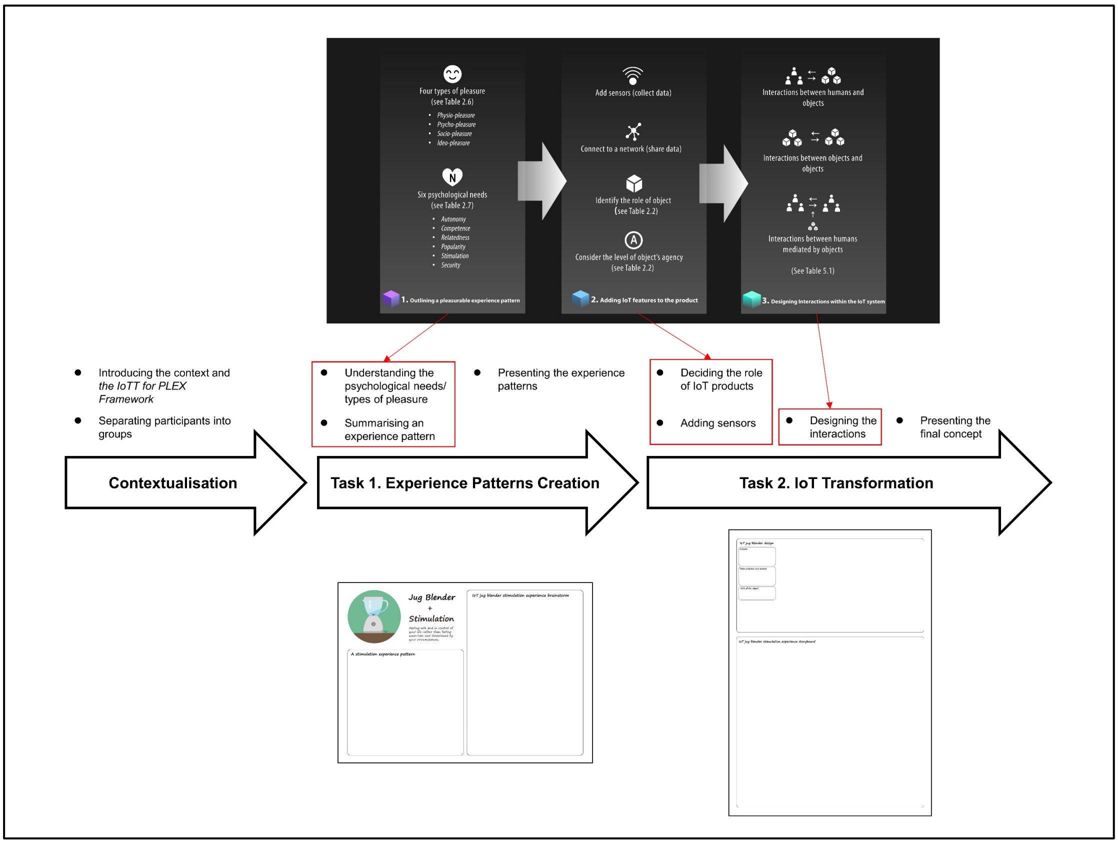


**Figure 5.5 Workshop 3 structure – This illustrates how *the IoTT for PLEX Framework* was implemented in each task. Step 1 of the framework was applied in Task 1, while Steps 2 and 3 were applied in Task 2.**

### 5.1.2.4 Key Results

The participants contributed ideas about new pleasurable experiences designed by transforming analogue products into IoT products. The experience concepts developed by the participants are detailed in Figures 5.6 to 5.15 and summarised in Table 5.2. The results of the workshop were analysed from a process-oriented perspective, focusing on the accomplishment of the tasks and the three steps within *the IoTT for PLEX Framework*.

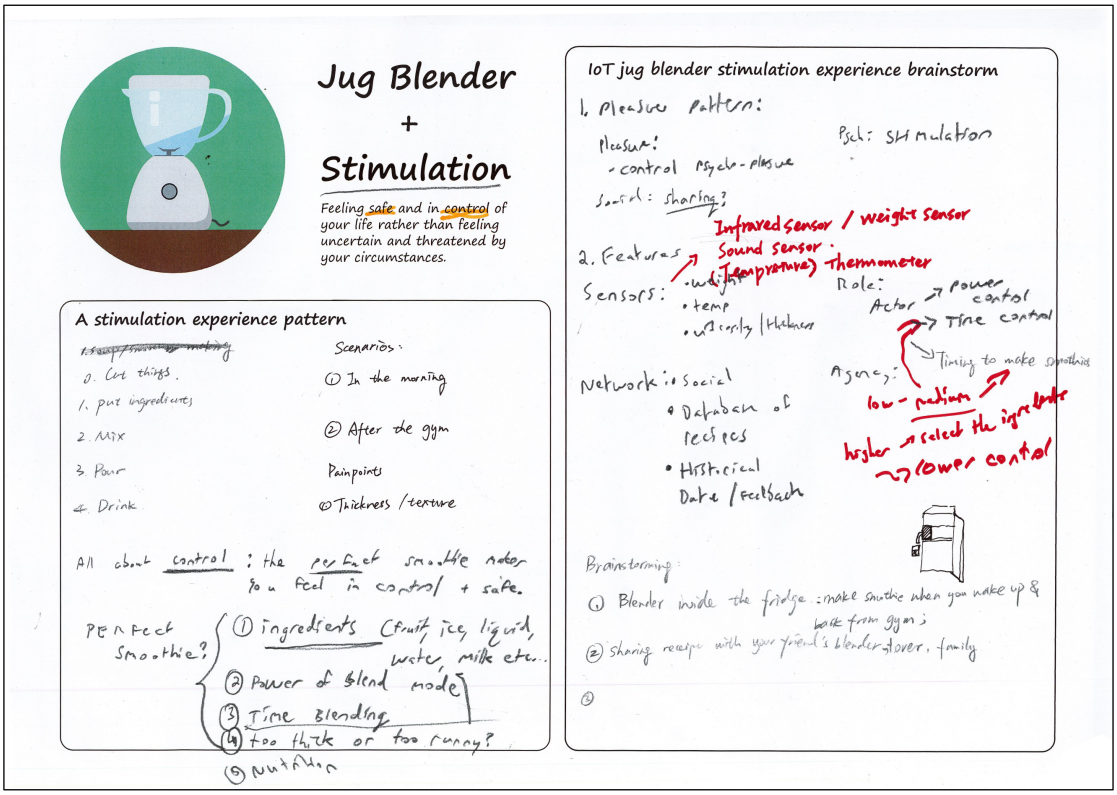


**Figure 5.6 Task 1 sheet completed by Group 1 – The group created an experience pattern of making their perfect smoothie in the morning or after a gym session. They identified the important factors while creating the perfect smoothie: taste, ingredients, thickness, blending time, nutrition, etc.**

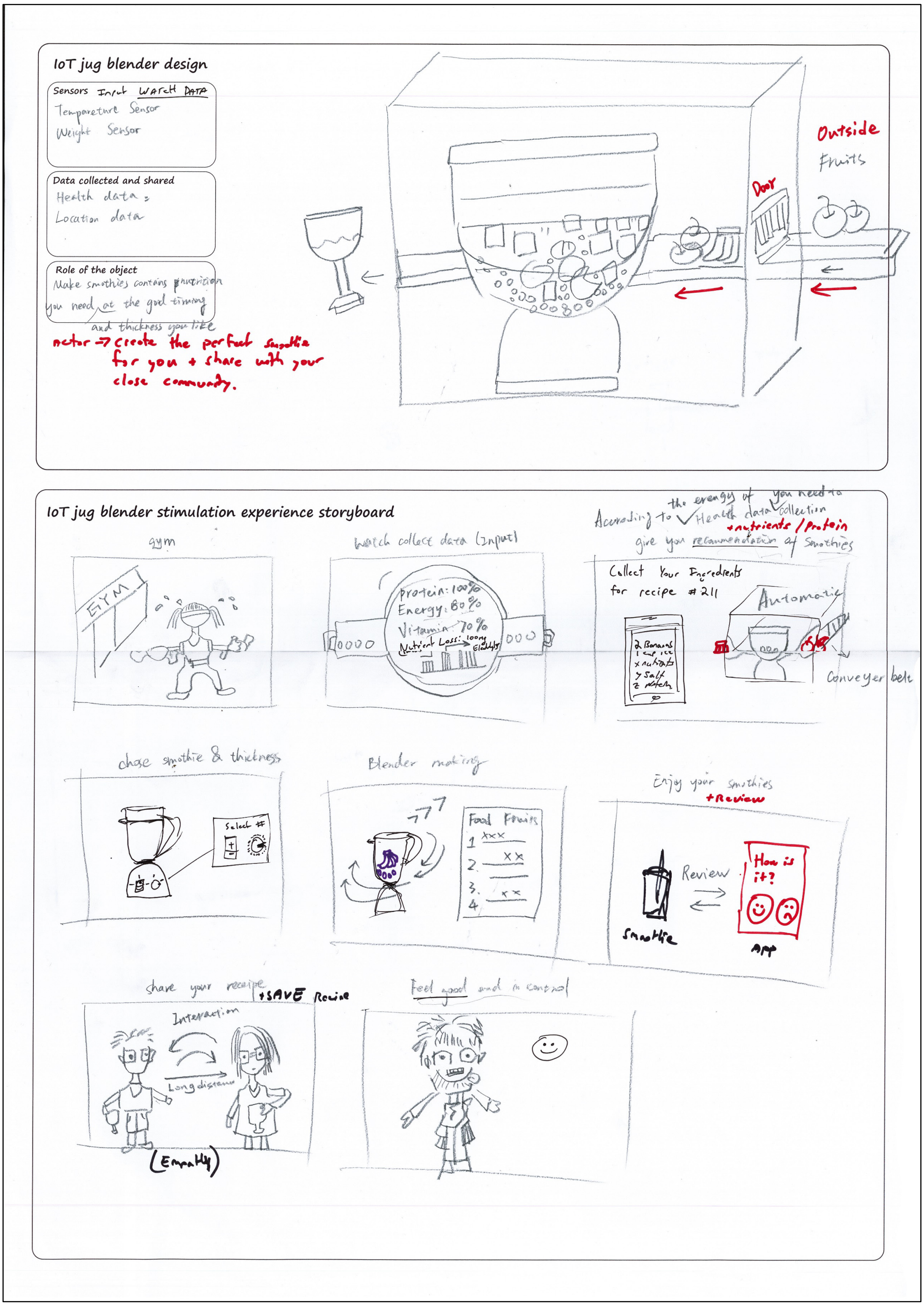


**Figure 5.7 Task 2 sheet completed by Group 1 – They envisioned a pleasurable experience associated with an IoT jug blender that automatically creates perfect smoothies. Users can share recipes in an online community, track their nutrition via smartwatches during exercise, and receive ingredient recommendations from a cloud service based on their activity. Ingredients are placed on a conveyor belt for selection and blending. After making a smoothie, users review it on a mobile app, influencing future ingredient suggestions by the cloud service. This interactive system encourages community engagement and fulfils the psychological need for stimulation by allowing users to share and compare their recipes.**

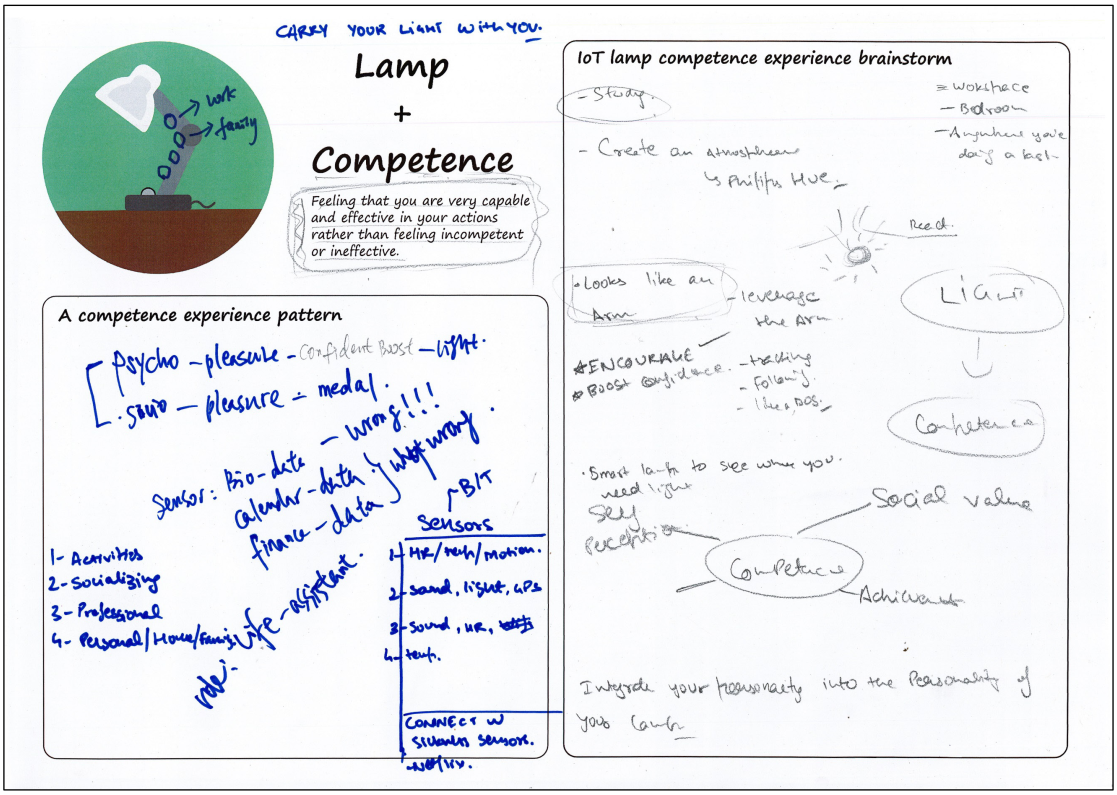


**Figure 5.8 Task 1 sheet completed by Group 2 – They identified an experience pattern that uses different colours of medals to encourage people and build their confidence which also elicits psycho-pleasure and socio-pleasure.**

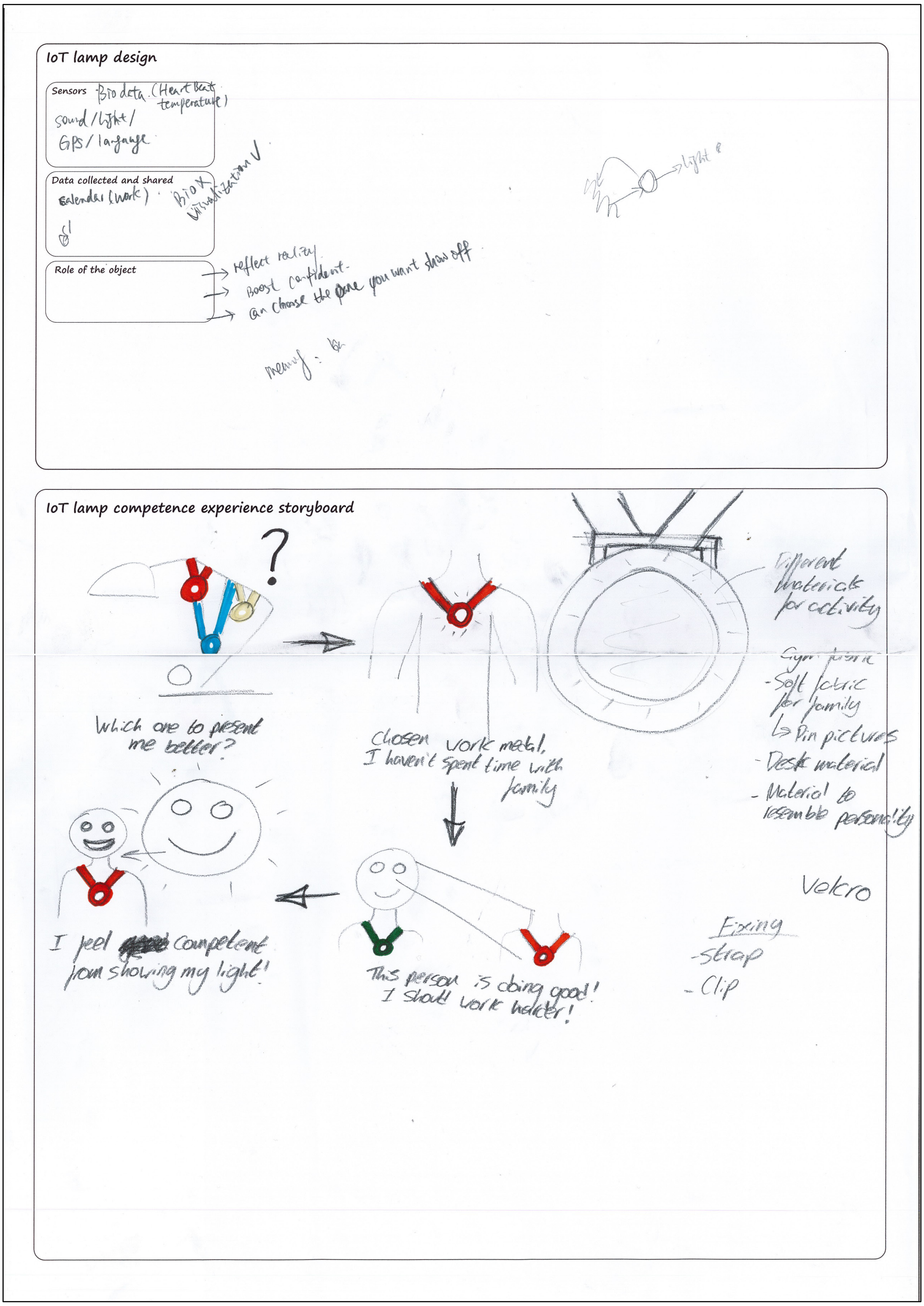


**Figure 5.9 Task 2 sheet completed by Group 2 – They envisioned an experience associated with an IoT lamp with three metal-like components. These components can be worn around the neck to communicate competencies via light colours. These components charge on the lamp's arm when not in use and connect to the internet to access data from users' online calendars. Users assign colour codes to different tasks in their calendars, and when a task is marked as finished, the corresponding component lights up. Users can choose which component to wear, reflecting their competences to colleagues. This visual display of tasks and competences allows users to self-evaluate and potentially fulfils a psychological need for competence by comparing achievements.**

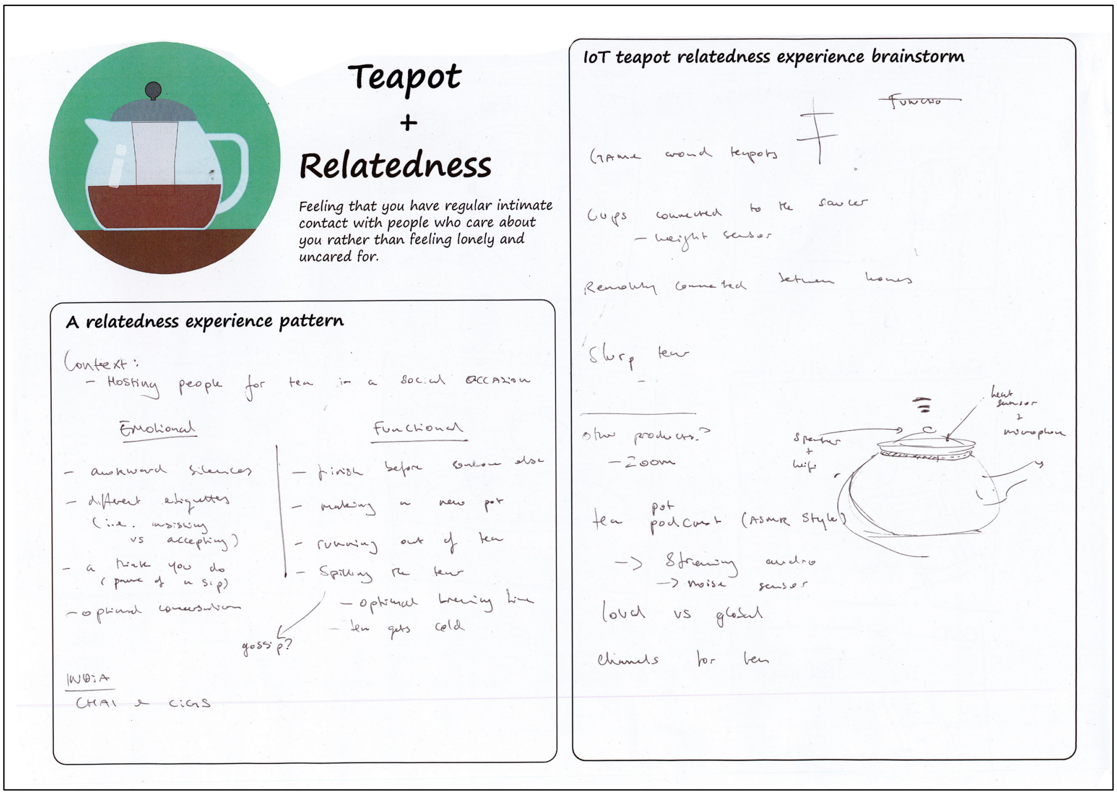


**Figure 5.10 Task 1 sheet completed by Group 3 – They summarised an experience pattern related to making tea for ten on a social occasion, allowing participants to communicate the culture of tea drinking in their respective countries.**

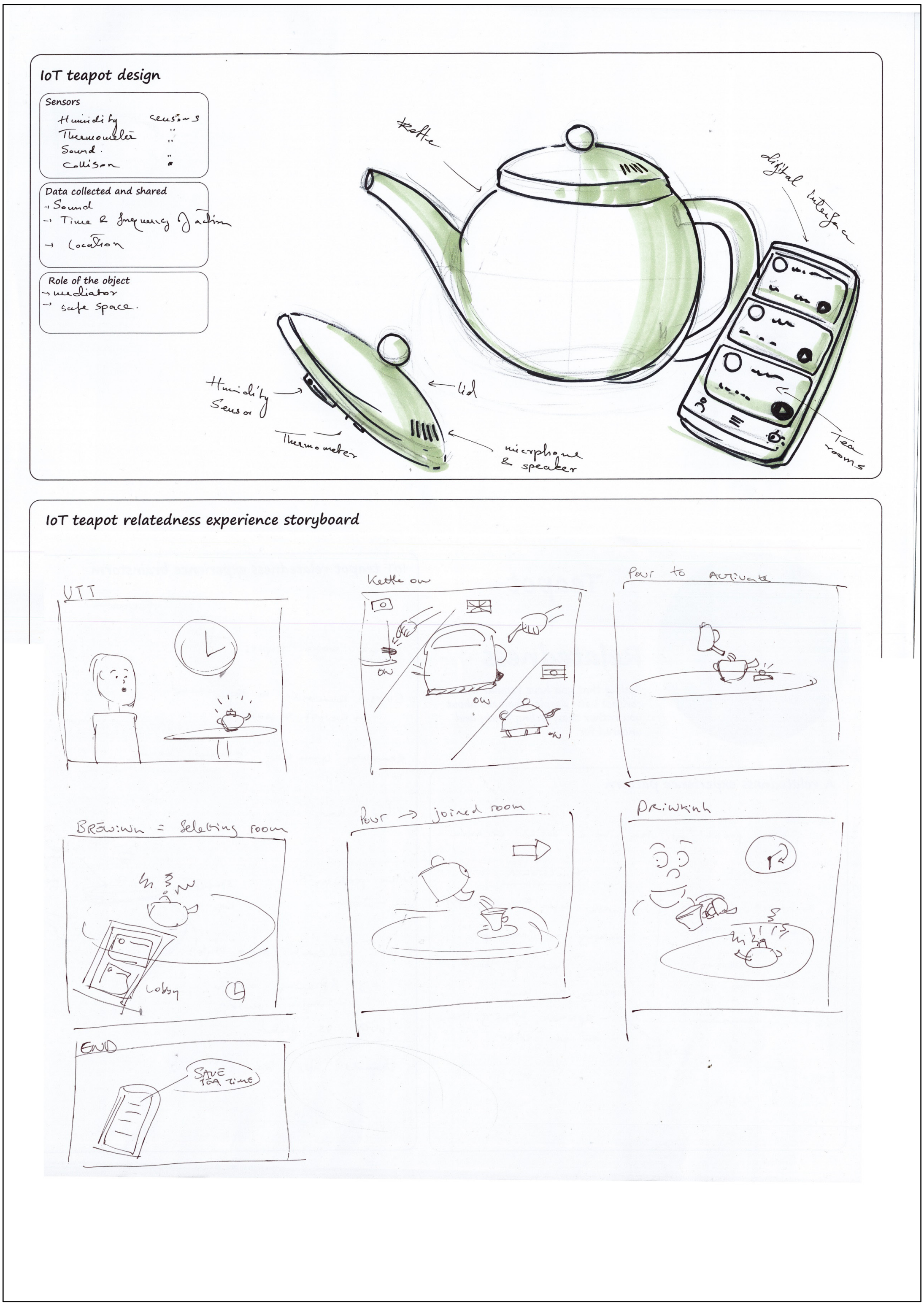


**Figure 5.11 Task 2 sheet completed by Group 3 – Their final pleasurable experience concept is that users communicate their tea cultures online at a universal teatime using an IoT teapot. The IoT teapot is equipped with temperature and humidity sensors, a microphone and a speaker. Users pour hot water into the IoT teapot, which triggers the sensors and connects to the internet. Depending on the tea's brewing time, users join specific online tearooms. The microphone and speaker enable real-time communication with others in the virtual room, fostering a sense of relatedness among users from similar cultural backgrounds.**

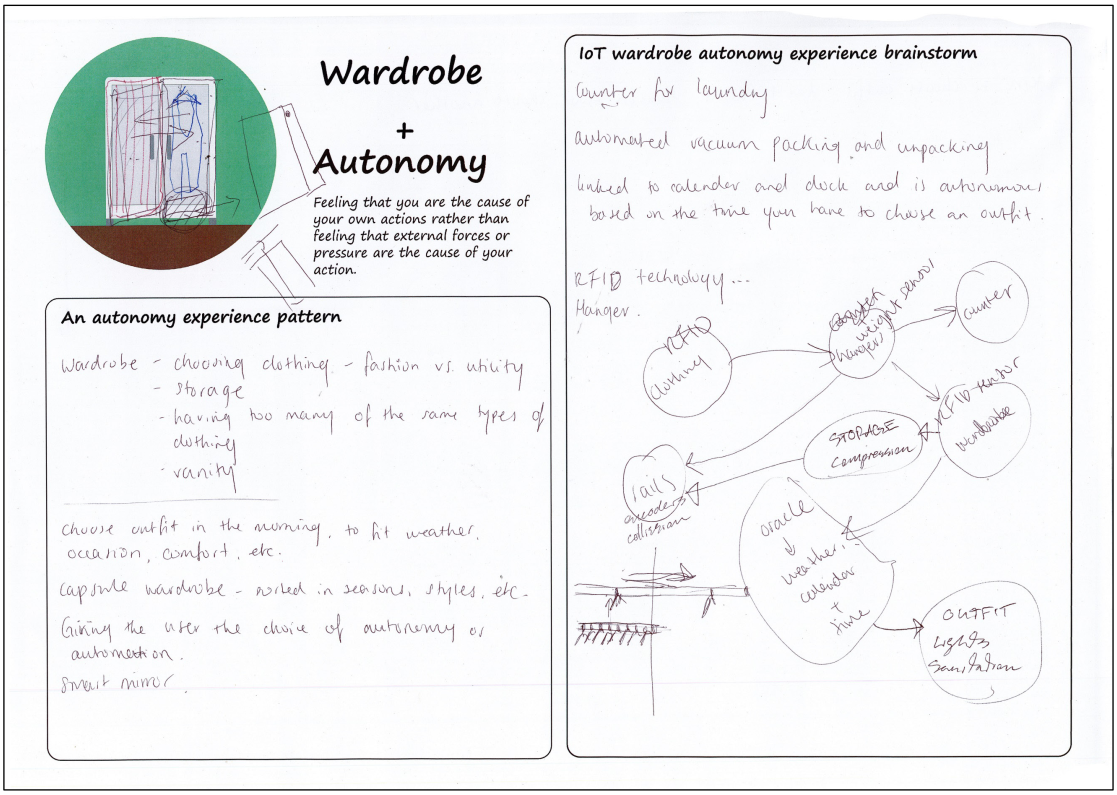


**Figure 5.12 Task 1 sheet completed by Group 4 – They identified an experience pattern for autonomy in clothing-related activities, proposing that tasks from washing and packing to selecting outfits could be automated by a machine.**

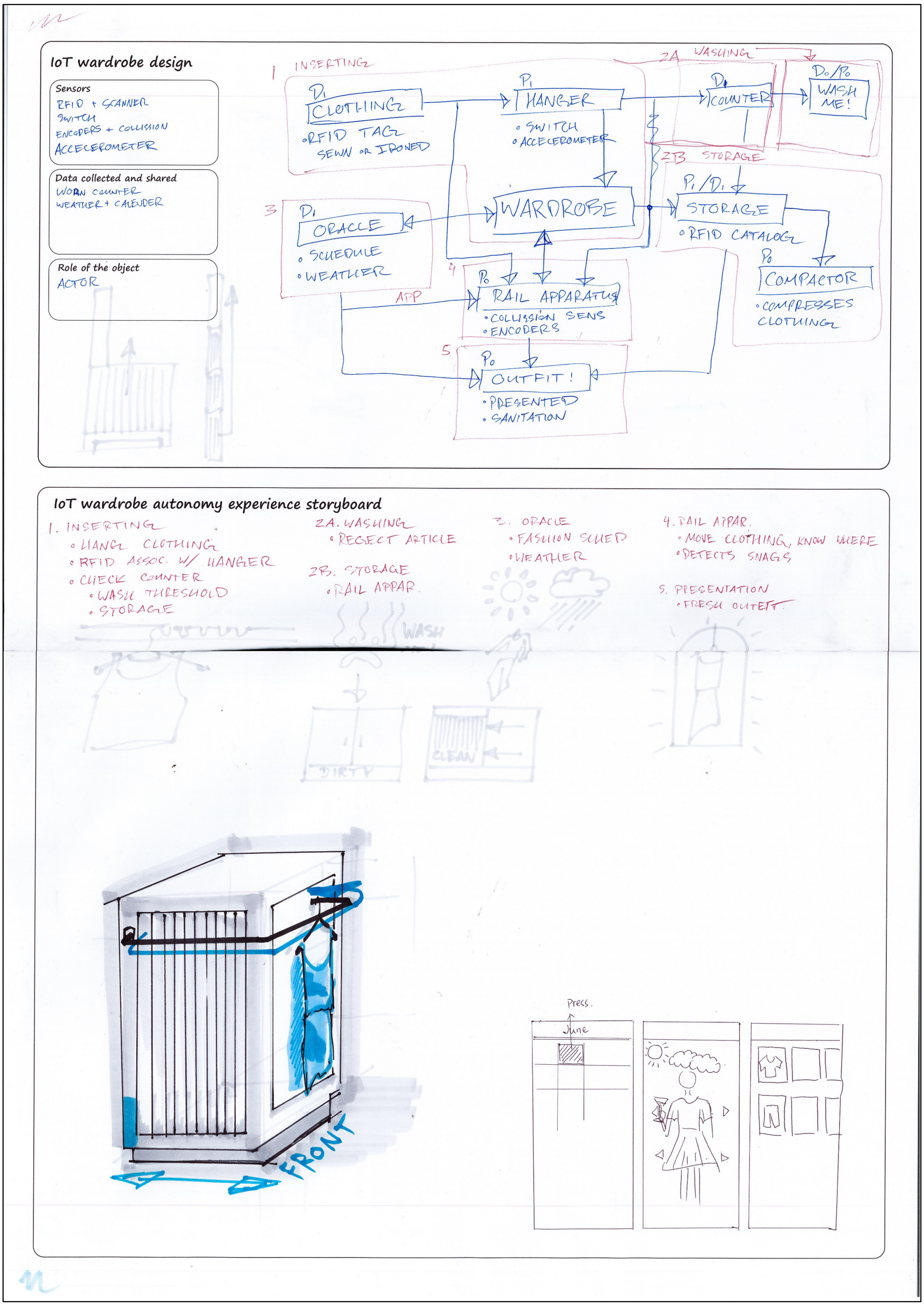


**Figure 5.13 Task 2 sheet completed by Group 4 – Their final pleasurable experience concept was associated with an IoT wardrobe that users can switch between "automatic" and "self-control" modes to manage garments based on their needs. Equipped with an RFID reader, a rotating hanging rail with an encoder, a collision sensor, and an accelerometer, the wardrobe organises and cleans garments by detecting RFID tags sewn onto them. It automatically sorts dirty items to the laundry basket and clean items to storage, where it also compresses out-of-season clothes to save space. Integrated with users' calendars and internet fashion trends, it recommends outfits based on the season, occasion and current styles, addressing the psychological need for autonomy.**

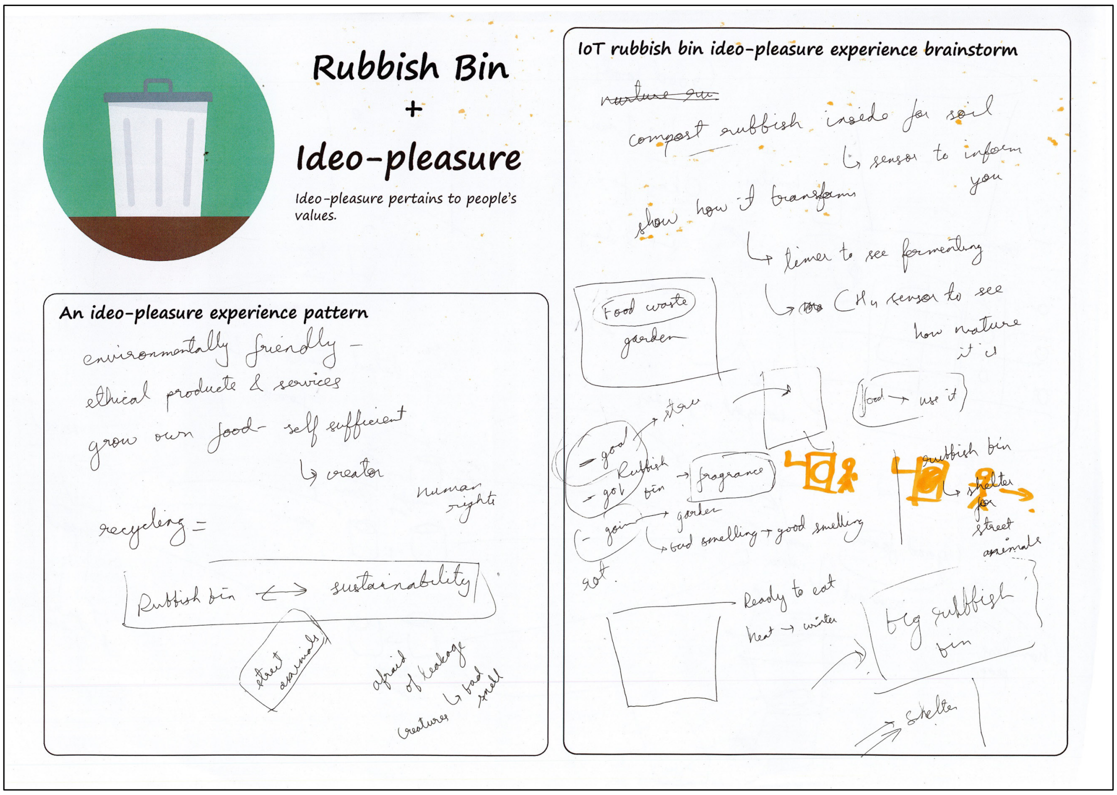


**Figure 5.14 Task 1 sheet completed by Group 5 – They chose the design theme "rubbish bin for ideo-pleasure" and developed an experience pattern of collecting waste food from bins to give to the homeless. However, during the discussion after Activity 1, other participants questioned the ethics of providing waste food to homeless people.**

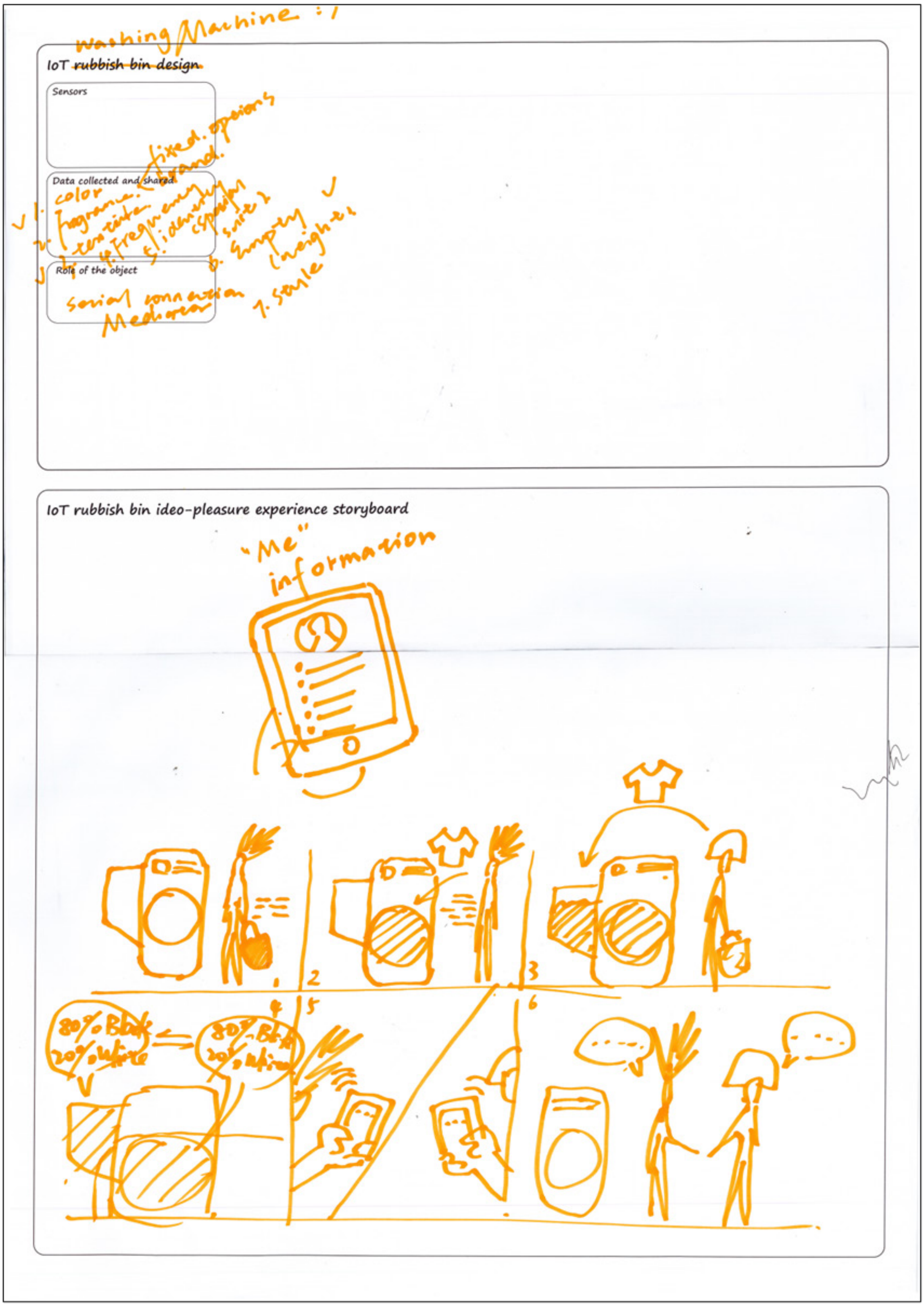


**Figure 5.15 Task 2 sheet completed by Group 5 – Finding it challenging to develop a new experience pattern for a rubbish bin in Task 1, they switched their design theme to "washing machine for socio-pleasure" in Task 2. They transformed a washing machine into an IoT product designed to elicit socio-pleasure by enabling users to connect with others who have similar tastes in clothing colours. The IoT washing machine, placed within a laundry service, incorporates a colour sensor in its drum. When the colour compositions of two users' clothes are sufficiently similar, it sends notifications through the laundry app, facilitating communication and social interactions among users.**

**Table 5.2 A comparison of concepts developed in Workshop 4.**

| Group | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| ***Analogue product on the task sheet*** | Jug blender | Lamp | Teapot | Wardrobe | Rubbish bin/ Washing machine |
| ***Design Aim*** | Stimulation | Competence | Relatedness | Autonomy | Ideo-pleasure/ socio-pleasure |
| ***Pleasurable experiences*** | Making a perfect personalised smoothie after fitness training | Presenting task accomplishments to colleagues | Connecting with people who are having tea at the same time from a distance | Receiving automatic recommendations for outfits | Connecting with people who live nearby and share the same fashion taste |
| ***Role of the IoT product*** | The Actor | The Actor | The Actor | The Actor | The Actor |
| ***Interactions*** | Object-to-object interactions, Human-to-object interactions, Human-to-humans interactions | Human-to-object interactions, Human-to-human interactions | Object-to-objects interactions, Human-to-object interactions, Human-to-humans interactions | Object to objects interactions, Object-to-human interactions, Human-to-object interactions | Object-to-object interactions, Object-to-objects interactions, Object-to-human interactions, Human-to-human interactions |

**Accomplishment of the participants' tasks**

Groups 1, 2, 3 and 4 completed both tasks during the workshop. However, Group 5 encountered challenges and was unable to finish their first task. They found the task, which aimed to link ideo-pleasure to the function of a rubbish bin, particularly difficult. Their initial ideas received some negative feedback during the discussion, leading them to switch to another product – the washing machine – and subsequently complete the second task.

*Step 1: Outlining a pleasurable experience pattern*

This is the most important step in this workshop because participants must first grasp the pleasure-driven design theories before they can effectively shape IoT products towards creating pleasurable experiences. Most groups (1, 2, 3 and 5) demonstrated a clear understanding of the pleasure or psychological need presented on their task sheets, in line with how I introduced it during the presentation. However, Group 4 interpreted the need for autonomy differently from the principle defined in *the IoTT for PLEX Framework* adopted from Hassenzahl et al. (2010; 2013), that users feel they are the cause of their actions. In Group 4's concept of the IoT wardrobe, the wardrobe seemed to possess more autonomy than the users, and it was unclear how the IoT features could facilitate users' autonomy in this context. (In their concept, switching to the automatic mode would increase the wardrobe's "autonomy" but decrease that of human users. The self-control mode did not differ from using a normal wardrobe.) After understanding the pleasure or psychological need in their task, participants outlined their pleasurable experience patterns based on their personal experiences. For example, two participants in Group 3 had a habit of drinking tea with their families, so they summarised an experience pattern of communicating with people around the world while drinking tea to fulfil the psychological need for relatedness.

*Step 2: Adding IoT features to the product*

In this step, the participants integrated digital sensors into their analogue product from the task sheet, effectively transforming it into an IoT system. Given that 80% of the participants (n = 12) had prior experience working on IoT projects, they were able to select sensors based on their previous knowledge. Interestingly, all the concepts developed in the workshop embedded digital sensors, except for Group 3's concept. Group 3's concept of the lamp for competence did not include any sensor but rather exchanged data with users' online calendars. Additionally, the participants carefully considered the level of agency and decided on the roles of the IoT products they developed. All participants' IoT products fell into Cila et al.'s category (2017) of "the Actor" (see Table 2.2) – capable of gathering data and reacting to users' actions. However, they were not augmented to generate their function on their own, so they could not be classified as "the Creator". Through this categorisation of IoT products, I noticed that participants grasped the concept of agency and were able to make informed decisions by selecting one role from the three available options.

*Step3: Designing interactions in the IoT system*

In this step, the participants focused on designing specific interactions for their concepts, considering how users would perceive these experiences through their interactions with IoT products. These interactions were closely linked with the functions of the use scenarios. For instance, Group 1 designed an IoT jug blender specifically for producing the perfect smoothie after a fitness exercise. Based on the function of a jug blender and the scenario of making a smoothie, they designed interactions that involved the jug blender exchanging ingredient data with a smart fridge, providing smoothie thickness based on users' customisation, and allowing users to share their recipes online with others. It was noteworthy that all the groups' ideas included multiple types of interactions within an IoT system when they used the 16-type interaction table (see Table 5.1) within *the IoTT for PLEX Framework*. In their concepts, Groups 1, 2, 3 and 5 created interactions between objects, interactions between humans and objects, and interactions between humans mediated by objects. However, Group 4's concept did not involve interactions between humans. Their concept was a wardrobe designed to fulfil psychological needs related to autonomy, which interacts with clothes through RFID tags and with users by gathering their fashion preference information and recommending outfits accordingly.

**Feedback from online questionnaires**

In the questionnaire, participants were asked to provide feedback on each step of *the IoTT for PLEX Framework* (refer to Appendix M for detailed feedback). To measure their feedback, rating-scale questions were employed. Participants rated the difficulties of each step, the effectiveness of the framework, and the impact of the framework on their future practices. The mean ratings for each question were calculated for comparison. The mean ratings for the difficulty of the three steps in the framework were 0.67, 0.87 and 0.83 respectively, all falling between "natural" (0) and "slightly easy" (1). This suggests that the difficulties of the three steps were not significantly different. Regarding the effectiveness of the framework, it received positive feedback with a mean of 1.40, lying between "slightly effective" (1) and "very effective" (2), with 13.33% rating it "slightly effective", 53.33% "very effective" and 13.33% "extremely effective". Moreover, participants provided positive feedback on the influence of the framework on their future practice, with a mean rating of 1.93, which is close to the level of "very influential" (2). In general, the feedback was positive: participants believed the framework and workshop allowed them to acquire new insights including the understanding of pleasure-driven theories, the role of the objects in the network and the relationship between IoT products and their pleasurable experiences.

**Feedback from interviews**

Three interviewed participants (P2, P12 and P14) shared insights and feedback on the design process, along with their understanding of pleasurable experiences and IoT products (refer to Appendix N for interview transcripts). They discussed how their understandings changed after the workshop, agreeing that the framework and the workshop had transformed their views on pleasurable experiences and introduced them to new principles regarding psychological needs in design. Moreover, they expanded their definition of IoT to include not only objects with digital sensors connected to networks but also immaterial elements within these networks. I was particularly interested in how participants translated psychological needs and pleasures into IoT concepts and the challenges they encountered during the design process. All mentioned that they started by summarising the experience pattern related to the psychological needs in their task, based on personal experiences, and then translated this pattern into IoT features.

Regarding their design process challenges, P12 highlighted difficulties in identifying correlations between psychological needs, the data collected, and interactions of the IoT product. P14 noted that the framework's lack of an evaluation method made it challenging to confirm the effectiveness of their interventions. Furthermore, P12 mentioned that the value of data was not well-understood by all designers which complicated data selection, while P14's group was concerned that overly autonomous IoT products might evoke user fear or discomfort. In discussions with participants about potential improvements to *the IoTT for PLEX Framework*, it was compared to established frameworks like the "Double Diamond" (Design Council, 2019) and the "Waterfall Methodology" (Gilb, 1985) commonly used in software development. Participants suggested a more flexible structure, clearer explanations of how different types of data and interactions influence various psychological needs, and the incorporation of an evaluation process.

#### 5.1.2.5 Reflections

*The IoTT for PLEX Framework*, as a new method, addresses sub-RQ2: "Which methods can support the creation of novel experiences through IoT transformations based on existing pleasure-driven design theories?" Through the workshop, the strengths and limitations of this method in supporting designers in envisioning pleasurable experiences through IoT transformations were identified.

**Strengths of *the IoTT for PLEX Framework***

*The IoTT for PLEX Framework* serves as a structured tool that facilitated the creativity of IoT experiences in the workshop. The pleasure-driven design theories integrated into the framework, drawing from psychological perspectives, were unfamiliar to some participants with a background in design. However, feedback from questionnaires and interviews showed that the majority of participants believed the framework was effective and easy to follow. The participants reported gaining valuable knowledge from our framework, which could potentially influence their future IoT practices. Guided by the framework, all participants successfully outlined a pleasurable experience pattern during Step 1, drawing from introduced psychological theories and their personal experiences. This shows that the framework effectively and efficiently negotiates pleasure-related knowledge with them in a limited time. In Step 2, the participants were encouraged to bridge these experience patterns with IoT features, leveraging their design expertise and prior experience working on IoT projects. The selections of digital sensors, data collection and the role of actors in design concepts were driven by the initial experience patterns. Table 5.1 in Step 3 promoted designers to thoughtfully consider meaningful interactions within the IoT network that would align with their choices from Step 2 and deliver a pleasurable experience. This step helped participants refine their IoT experience design concepts by adding further details to their proposals. The framework successfully covered the four important elements of an IoT creativity tool argued by De Roeck et al. (2014) – actor-centred, allowing expression in multiple ways, balancing tangible and service components, and triggering detailed interaction definitions.

While the market success of the new experiences developed in the workshop remains uncertain, a key outcome was that designers now recognise the opportunities and possibilities offered by IoT product transformation for experience design. Notably, their ideas incorporated three factors shaping experiences with IoT products: 1) the value of data gathered by IoT products and stored in the cloud, 2) the smart capabilities of IoT products, and 3) the interactions that allow users to perceive the pre-designed experience. Certain groups (Groups 2, 3 and 5) effectively utilised IoT features to improve the hedonic qualities of their products, showing the advantages of IoT products over their analogue forms in shaping experiences. The results and feedback from designers collectively indicated that the elements emphasised in *the IoTT for PLEX Framework* effectively supported the generation of new ideas for innovative experiences in their design activities. It also showed that the strategy of analogue product augmentation (Kuniavsky, 2010) is effective in designing innovative pleasurable experiences for IoT products.

Compared to existing IoT creativity-supporting tools that include card sets – e.g., IoT Deck (Chen, Liang & Chiang, 2011), Tiles (Mora, Gianni & Divitini, 2017) and Loaded Dice (Berger et al., 2019) – *the IoTT for PLEX Framework* demonstrates a more streamlined structure. Rather than overwhelming participants with extensive information that requires considerable reading time during the workshop, the framework presents a concise workflow that highlights key factors and facilitates co-design. The three steps of the framework provided the participants with discussion topics and enabled them to apply design skills. They were required to share their understanding of the new knowledge and actively contribute their ideas at each step.

Compared to existing IoT creativity-supporting tools that guide the design of comprehensive user experiences (e.g., The IoT Design Deck (Dibitonto et al., 2018), MappingTheIoT (Vitali, Rognoli & Arquilla, 2016)), *the IoTT for PLEX Framework* offers a more innovative way of thinking. The framework does not aim to cover all aspects of an IoT product's experiences. Instead, it encourages placing experience before product (Hassenzahl, 2010) and focuses on a specific type of pleasurable experience. Both divergent thinking and convergent thinking – as included in the Double Diamond design process (Design Council, 2019) – were observed in the design process. Initially, participants generated different experience patterns and then reached a consensus within their groups. Consequently, they brainstormed ideas for sensors, levels of agency, and interactions to adapt the experience pattern to a new context. Finally, they refined these elements to select the most suitable ones for the final experience design concepts. *The IoTT for PLEX Framework* supported collaborative IoT experience creativity and encouraged diverse forms of design thinking the across different stages.

*The IoTT for PLEX Framework* offers benefits not only to product designers, interaction designers and experience designers but also serves as a research tool for design and HCI researchers. It provides a method for researchers to explore novel experience design through IoT transformations and to understand the creative process of designers. Workshop 3 can be conveniently replicated using *the IoTT for PLEX Framework* and the task sheet. My presentation slides (see Appendix H) can assist fellow researchers in comprehending and introducing the framework to a wider array of participants. New tasks can be readily created using the templates of my task sheets. Moreover, the questions featured in my survey and interviews can serve as a foundation for designing new surveys and interviews to gather feedback from participants.

**Limitations of *the IoTT for PLEX Framework***

However, the workshop outcomes and participants' feedback also revealed challenges when employing *the IoTT for PLEX Framework* in design activities. Firstly, participants found it difficult to determine which types of collected data would best elicit pleasure or fulfil psychological needs in their tasks, alongside identifying effective interactions within an IoT system. To address this, explicit case studies that demonstrate the detailed influence of collected data, object agency and how different types of interactions match various types of pleasure and psychological needs could be beneficial for an IoT experience creativity-supporting tool. Secondly, participants expressed difficulty in evaluating the success of envisioning pleasurable experiences. They suggested that incorporating evaluation processes from other product development frameworks, such as the Double Diamond Framework (Design Council, 2019) and Agile Methodology (Dybå & Dingsøyr, 2008), could be valuable in this context. As discussed in *Section 2.3.2*, existing IoT creativity-supporting tools like the MappingTheIoT Toolkit (Vitali, Rognoli & Arquilla, 2016) do include criteria for evaluating IoT ideations. However, these tools predominantly focus on the product development aspect rather than the overall user experience. Therefore, Stage 3 of this research would involve hands-on engagement and the creation of design probes and prototypes as vehicles for evaluating pleasurable experiences.

**Limitations of Workshop 3**

The participants of Workshop 3 were early-career designers (aged 22-35) from multidisciplinary backgrounds pursuing a master's or PhD degree in design-related programmes, some studying in a second language. They all held a bachelor's degree, and some had prior professional experience. For improved clarity and real-world testing purposes, it would be beneficial to expand *the IoTT for PLEX Framework* to include designers practising in the industry as well as HCI researchers. This would allow for an investigation of how the framework might influence the practices of a more experienced cohort who do not have an institutional relationship with the academic researchers. Additionally, the experience design concepts developed in Workshop 3 were evaluated from a process-oriented perspective. I did not attempt to evaluate or rank the experience design concepts from participants. As a result, their success or pleasurability in the real world was not discussed.

### 5.1.2.6 Summary of Findings

Workshop 3 demonstrated that *the IoTT for PLEX Framework* is an effective method for enabling a group of early-career designers to envision pleasurable experiences in a design workshop. The framework exhibited its strengths by facilitating creative IoT experiences through a structured approach that encouraged designers to recognise the opportunities and possibilities offered by IoT product transformations for experience design, guiding them to focus on a specific type of pleasurable experience via its streamlined structure. These strengths highlight the value and contribution of the framework both as a design tool and as a research tool in design and HCI research. Although the framework has certain limitations, such as selecting appropriate sensors for collecting the right type of data for pleasure-driven purposes and evaluating designed experiences, these can be addressed in subsequent studies. This can be achieved by testing the framework with HCI researchers who possess a deeper understanding of digital data, providing physical tools to supplement ideation and developing research products to be tested in real-world scenarios. The findings of Workshop 3 have informed the design practices in Stage 4, which engaged HCI researchers to ideate using both the *IoTT for PLEX Framework* and three physical, hands-on research tools and afterwards a research product designed according to the framework was tested with users in an in-the-wild experiment.

## 5.2 Stage 3: Co-Speculating on The Future

After developing the new *IoTT for PLEX Framework*, I moved into Stage 3, which speculates on the future possibilities for how pleasure-driven approaches and the transformation from analogue products to IoT products impact human-object relationships. In this stage, I took on the role of researcher-designer, applying design theories to create probes and artefacts to inform new possibilities and future human-object relationships. This stage addresses sub-RQ3: "How do pleasure-driven experience design and the transformations from analogue to IoT products influence future relationships between human beings and networked objects?"

### 5.2.1 Workshop 4: Co-Speculating on Pleasure-Driven Design through IoT transformations with HCI researchers

#### 5.2.1.1 Context

In Workshop 4, I engaged HCI researchers in design activities which speculated on novel possibilities for designing pleasurable experiences through IoT transformations using pre-designed attachments. The design activities in this workshop followed the steps in *the IoTT for PLEX Framework*. Three psychological needs – relatedness, stimulation and meaning (see their meanings in Table 2.6) – were selected as design objectives. Three attachments embedded IoT features served as tools for material speculation, which facilitated the generation of innovative ideas based on participants' expertise. Workshop 4 aimed to achieve the following objectives: 1) to engage in co-speculation with HCI researchers to explore how my new framework, combined with material prototypes, facilitates new possibilities for novel experiences through IoT transformations 2) to provide a reflective perspective from HCI on the relationship between pleasure-driven design and the transformation from analogue products and 3) to assist me in developing a robust concept for the co-speculation experiment as subsequent practice. After obtaining ethical approval from the RCA Ethics Committee, I conducted Workshop 4 during my research visit to Open Lab at Newcastle University, UK, with a total of seven participants, all of whom were HCI researchers with expertise in IoT and/or physical computing. The participants were recruited through an invitation email sent by the staff to all researchers at Open Lab. All interested respondents who registered were included, comprising one female and six males from diverse cultural backgrounds (five British, one

Chinese, and one of unknown origin). Their professional backgrounds included academia (n=5) and a combination of academia and industry (n=2). Five participants held a PhD degree in HCI-related fields. To ensure anonymity, the participants will be referred to as P1 to P7.

#### 5.2.1.2 Method: Material Speculation and Co-Speculation

The methods applied in Workshop 4 include material speculation and co-speculation. Design researcher Ron Wakkary and his colleagues (2015) proposed a method for design research called *material speculation* based on critical and speculative design (Dunne & Raby, 2013). According to their definition:

> "Material speculation emphasises the material or mediating experience of specially designed artefacts in our everyday world by creating or reading what we refer to as counterfactual artefacts. Material speculation utilises physical design artefacts to generate possibilities to reason upon (Wakkary et al., 2015:p.1)."

Two notable research projects that applied material speculation are *Morse Things* (Wakkary et al., 2017) and *Table Non-table* (Hauser et al., 2018). In the *Morse Things* project, the researchers created a series of interconnected ceramic bowls that communicate through Morse Code. These bowls were distributed to six interaction design practitioners and researchers who lived with them for six weeks. After the participants had experienced the bowls, they joined a workshop where they shared their interpretations of the artefacts and engaged in co-speculation with the researchers. The study's findings revealed the complex and ambiguous relationship between humans and IoT objects, as well as the potential for creating new types of objects beyond human-centred and non-digital technologies in the context of home IoT environments. In the *Table Non-table* project, the researchers constructed a table-like structure using stacked common-stock paper and an aluminium chassis that moved slowly over short distances. This structure was deployed in various environments over a span of four and a half years. The deployment of the Table Non-table revealed how theory is shaped and informed by practice in design research, highlighted the relevance of postphenomenology as a useful framework in HCI, and identified future research opportunities in the domain of human-object relationships.

*Co-speculation* is a method developed by Wakkary et al. (2018) building upon material speculation. It aims to investigate the relationships between objects and humans through collaborative design involving artefacts, designers and experts from other fields. Co-speculation differs from co-design for social innovation (Manzini, 2015) in that designers play a distinct role in this method by producing artefacts. These artefacts are then deployed to experts in various fields who live with them, record data and provide feedback and opinions based on their expertise. The analysis of their collective envisioning process is expected to contribute to the researcher's understanding and insights about human-object or human-technology relationships, potentially leading to new design implications. In the *Tilting Bowl* project, the researcher created a ceramic bowl that unpredictably tilts multiple times throughout the day. This bowl was deployed for six trained philosophers to live with. Through a postphenomenological inquiry conducted with the philosophers, the researchers explored the relationships between humans and technological artefacts. The co-speculation with the philosophers provided Wakkary et al. with a foundational and comprehensive understanding of how humans and digital objects mutually shape each other from a philosophical perspective.

Both speculation and co-speculation methods involve design researchers in creating artefacts to investigate the complex, nuanced and dynamic relationships between humans and technology. They seek to address the participatory weaknesses in speculative design methods and are adapted within the PD method category. In Workshop 4, I selected these two methods because the results from Workshop 3 revealed that physical prototypes might better help participants envision pleasurable experiences based on the framework, and materials would be more straightforward for participants to imagine interactions. The two methods also enable me to inquire into the relationship between pleasure-driven design and IoT transformations in collaboration with HCI researchers through material artefacts, which exploits my skills as a designer.

### 5.2.1.3 Research Design

I created three attachments to be used as tools for participants to transform analogue products into IoT products (see Figure 5.16 to Figure 5.18). Each attachment comprises various electronic components and a development PCB equipped with a Wi-Fi module. These attachments are designed for easy integration with digital sensors and can be attached to everyday household items.

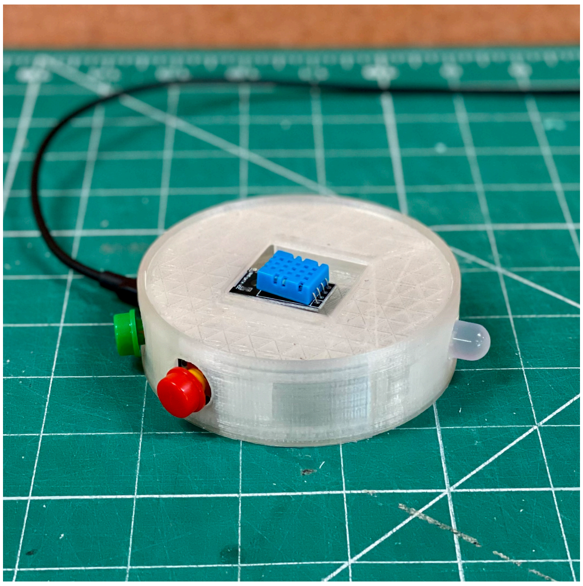

**Figure 5.16 The prototype of Attachment 1 – a flat cylinder that features a top-side slot for embedding a digital sensor, incorporating two buttons and an LED light.**

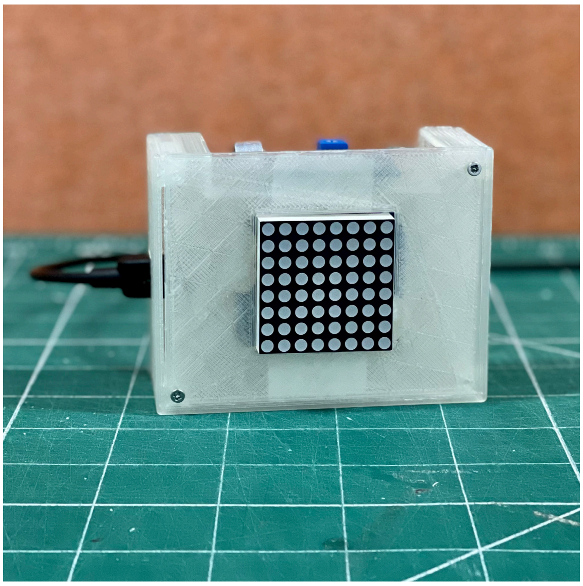

**Figure 5.17 The prototype of Attachment 2 – a box-shaped device that includes a bottom-side slot for embedding a digital sensor and an LED matrix to express the characteristics of the attached home appliance.**

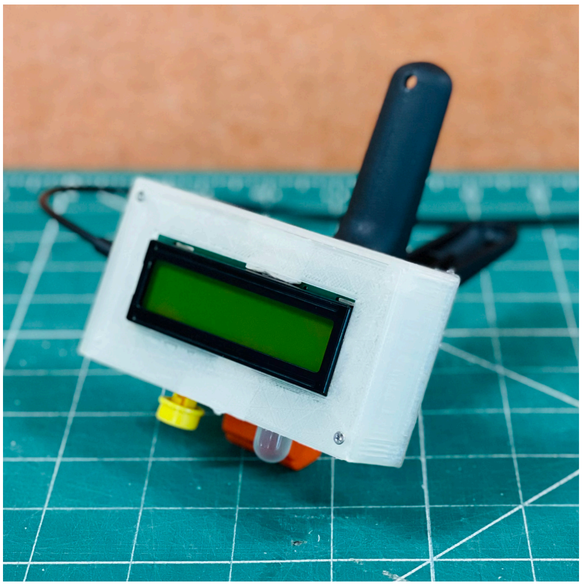

**Figure 5.18 Prototypes of Attachment 3 – a clip-shaped device that incorporates an LCD screen for data display, a button for sending signals, and an LED light.**

The workshop was conducted in a meeting room at Open Lab. Before the workshop started, a camera was set up in front of the meeting room to record the proceedings, and consent forms (see Appendix O for details) were made available on the table alongside three pre-built prototypes. Upon entering the meeting room, participants were given 10 minutes to review the consent form, seek clarification if needed, and sign it. Subsequently, I delivered a five-minute presentation to outline the workshop's context. The participants then engaged in three design activities. In each activity, participants developed a concept for a pleasurable experience by fulfilling a psychological need and utilising an attachment to transform a domestic analogue product into an IoT product. In Activity 1, participants were tasked with fulfilling the psychological need for relatedness by utilising Attachment 1. In Activity 2, participants addressed the need for stimulation, utilising Attachment 2. Lastly, in Activity 3, participants were required to fulfil the need for meaning, utilising Attachment 3. The selection of psychological needs for this workshop was influenced by the end of the COVID-19 pandemic, which allowed me to collaborate with other researchers in person once again. As previously mentioned, I faced significant challenges in recruiting participants during the pandemic, and my understanding of pleasure was shaped by this difficult period. The pandemic restricted in-person research activities, left researchers feeling isolated and occasionally unmotivated, and prompted many individuals to confront illness, loss or a re-evaluation of life's meaning. Consequently, the psychological needs for relatedness, stimulation and meaning were selected as focal points for this workshop.

A set of inspirational cards (see Figure 5.19) was placed on the table to inspire participants about which types of domestic analogue products could be transformed into IoT forms. Before each activity, I presented the definition of the psychological need as a design objective, a pre-built prototype of the corresponding attachment and an example concept of a pleasurable experience developed by me. Participants were required to sketch their ideas on a task sheet, which listed potential sensors that could be embedded in the attachments. During each 15-minute activity, participants followed the three steps of *the IoTT for PLEX Framework*. First, they learned about the psychological need targeted in the activity. Next, they brainstormed potential analogue products for the attachment and considered additional sensors that could be embedded. Finally, they explored how the IoT product would interact with people. After each activity, participants presented their ideas. The workshop concluded with the collection of the participants' task sheets for further analysis once all three activities were completed.

During the planning of the workshop's design activities, inspiration was drawn from Gaver et al.'s perspective (2003) on ambiguity as a valuable design resource. Gaver et al. argued that ambiguity can serve as a resource for design that encourages greater engagement between humans and machines. Ambiguity in information originates from the artefact itself; ambiguity in context can stimulate people to question their understanding of technology, while ambiguity in relationships can prompt individuals to project their subjective experiences and perspectives onto new situations. Hence, in the workshop, information about the three attachments and the corresponding psychological needs for each activity was provided. However, the context and the relationship between the IoT products and users were intentionally left ambiguous. This approach aimed to foster participants' reimagining of pleasurable experiences and the transformations from analogue to IoT products.

**Figure 5.19 Inspiration cards and my ideas pre-set up on the table (upper), participants generating ideas (middle), participants handing on the attachments (right).**

### 5.2.1.4 Key Results

In Activity 1, participants utilised Attachment 1 to develop IoT experience concepts that fulfil the need for relatedness (refer to Figure 5.20). The analogue products considered for integration with Attachment 1 included lamps, bedside tables, plant pots, washing lines, microwaves and blenders. Some participants' ideas (P1, P2, P3, P4) focused on connecting individuals across different locations, while others (P5, P6, P7) aimed to facilitate connections among individuals within the same physical space. In Activity 2, participants employed Attachment 2 to create IoT experience concepts that fulfil the need for stimulation (see Figure 5.21). They envisioned various ways to stimulate individuals in their daily routines using Attachment 2, which was conceptualised as being attached to cabinets, microwaves, fridges, fish tanks, bookshelves and beds. Notably, some ideas (P2 and P5) in this activity did not rely on connectivity to function; instead, their responses to users were based solely on data collected by local sensors. Employing LED matrices, some concepts aimed to be expressive, with the IoT products providing user feedback from the perspective of objects, thus fostering a sense of understanding human experiences and how to stimulate their lives. In Activity 3, participants utilised Attachment 3 to create IoT experience concepts that fulfil the need for meaning (refer to Figure 5.22). Attachment 3 has been incorporated into various analogue products including heaters, armchairs, guitars, washing lines, workshop desks, rubbish bins and even animals, such as cats. The large-sized images of these ideas can be found in Appendix P.

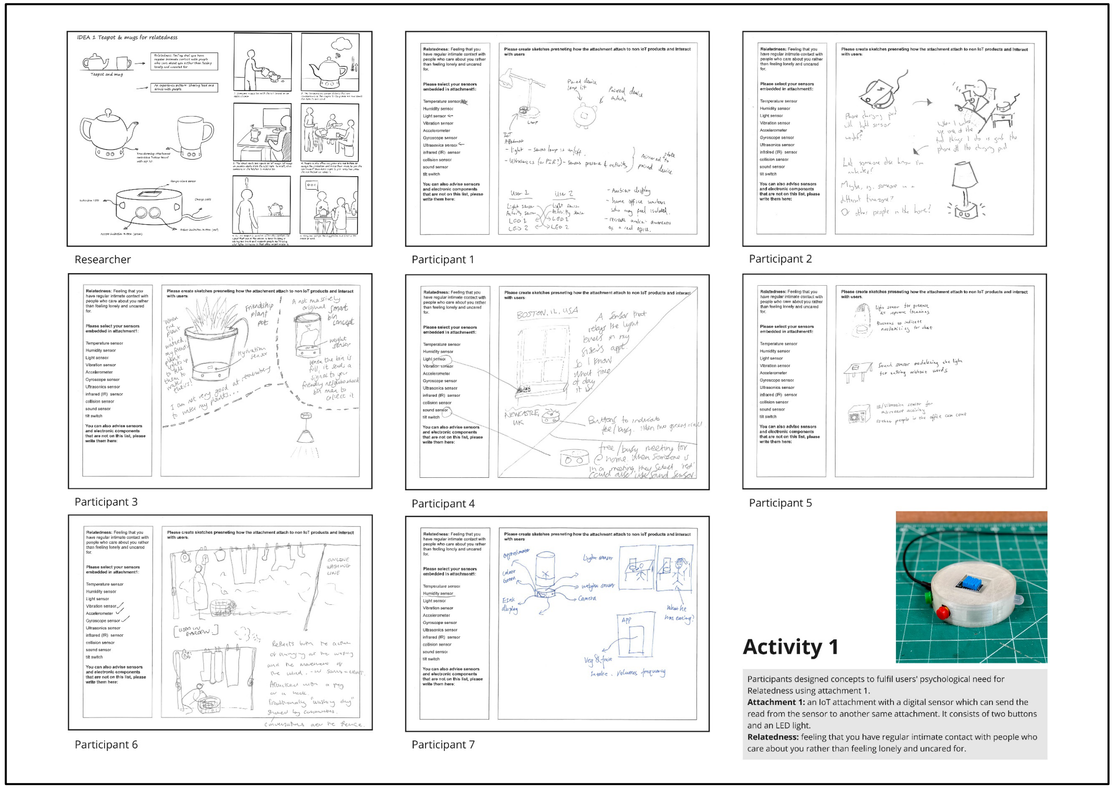


**Figure 5.20 Ideation in Activity 1: Fulfilling the need for relatedness by utilising Attachment 1 – My example idea involved using IoT tea pots and mugs in the office to send invitations to colleagues for a tea break; P1 designed a lamp to indicate the working status of home office workers to others; P2 proposed a wireless charging pad or speaker to facilitate communication with individuals in different time zones; P3 created an IoT plant pot that would enable two people in different cities to connect through the care of plants; P4 added the attachment to a work desk to facilitate a connection between him in Newcastle, UK, and his sister in Boston, US. The device would convey time differences by detecting the lighting in their flats and utilising a sound sensor to recognise if they are in a meeting; P5 generated three different ideas: an IoT lamp that detects the presence of people at separate locations through a light sensor and indicates their availability for a chat; an IoT meeting table with a sound sensor that modulates the ambient lighting based on the room's volume; and an IoT microwave that detects its activity through IR and vibration sensors, reminding people to come and collect their food; P6 suggested an interactive washing line embedding vibration sensors, gyroscopes, and accelerometers in the yards of terraced houses, which would facilitate communication with neighbours on laundry days through LED indicators; P7 designed an IoT blender that would provide users with information about previous users and the ingredients that had been added from the fridge.**

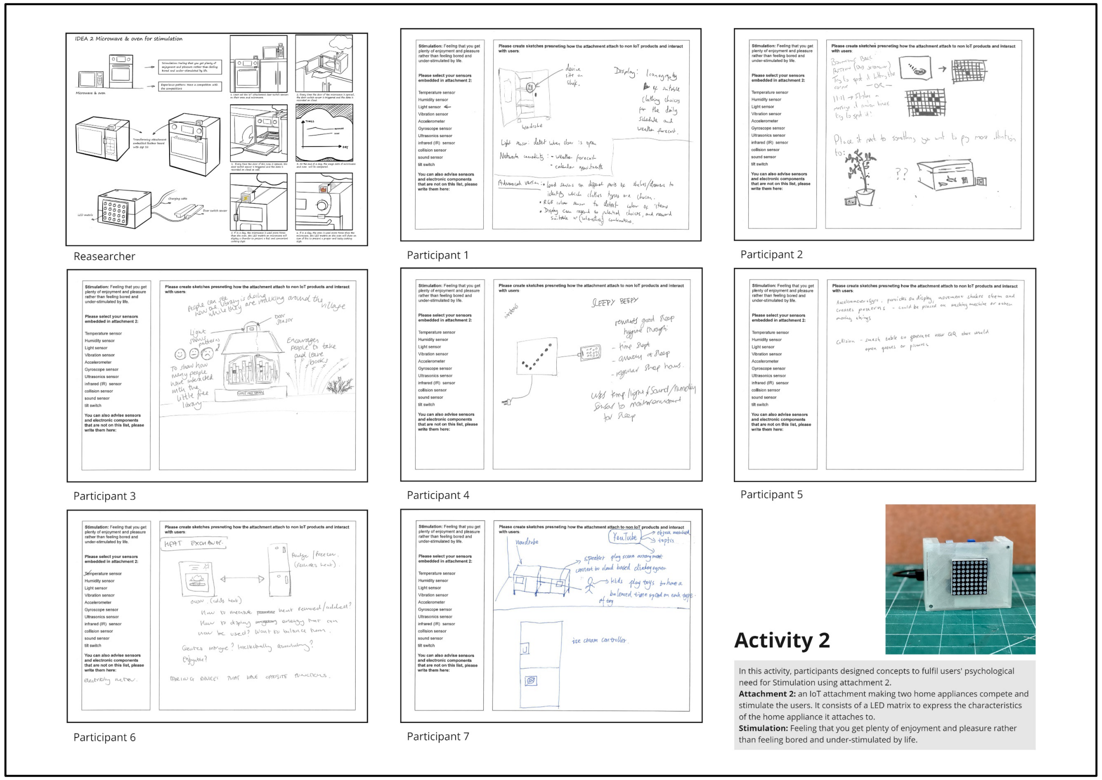


**Figure 5.21 Ideation in Activity 2: fulfilling the need for stimulation utilising Attachment 2 – My example idea involved creating an IoT oven and an IoT microwave that would demonstrate their usage to users and compete for usage; P1 developed the concept of an IoT cabinet that would recommend outfits based on the user's online daily schedule; P2 created a portable screen attached to a planter or a fish tank, featuring a randomly moving pattern to capture the user's attention; P3 came up with the idea of a mini library in the yard that would convey emotions when books are taken out; P4 designed a sleep tracker that collects data on sleeping patterns and provides feedback on the user's sleep quality; P5 created two concepts: the first embeds an accelerometer in a moving analogue product like a washing machine, where the movement of the machine controls the pattern displayed on the LED matrix, and the second involves embedding a collision sensor that generates a QR code on the LED matrix when the table is hit, linking to an image or quote; P6 proposed attaching it to both an oven and a fridge freezer, displaying the energy consumed on the LED matrix and facilitating an exchange of heat between the appliances to save energy by connecting analogue products with bidirectional functions; P7 developed two ideas for his child: the first attaches to the wardrobe containing his child's toys to detect the time his son spends with different types of toys, planning to use this data to manage his child's cartoon watching on YouTube, aiming to balance the time spent on various toys, and the second attaches to the freezer to display a scary face every time his child tries to eat ice cream as a warning.**

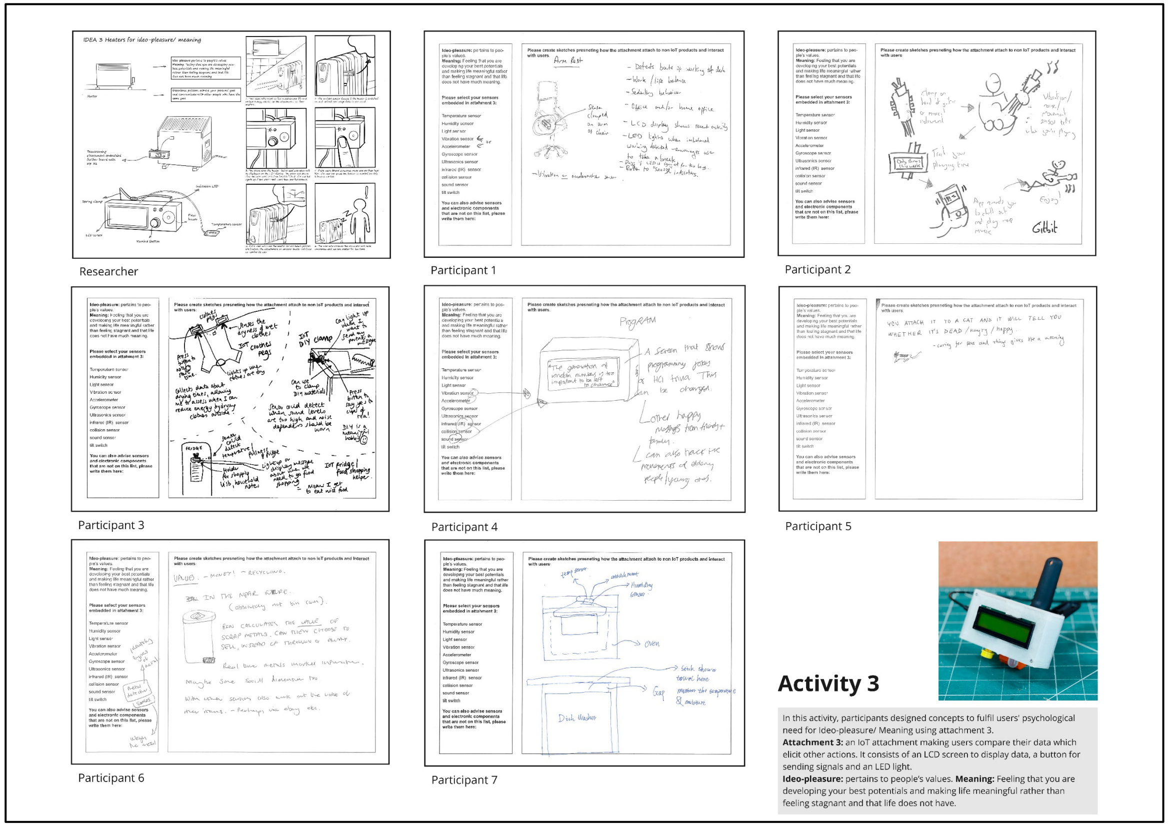


**Figure 5.22 Ideas generated in Activity 3: fulfilling the need for meaning utilising Attachment 3 — My example idea involved connecting heaters in two households living sustainably, allowing their users to remind each other to save energy; P1 created an IoT armchair that encourages home office workers to take breaks after extended periods of sitting, aiming to maintain a healthy work-life balance; P2 designed an IoT guitar that tracks playing hours and enhances the practice experience to make it more enjoyable; P3 created three different ideas: the first is an IoT clothes peg attached to a washing line that detects the dryness of wet clothes, thereby reducing dryer use and saving energy; the second is an IoT clamp for DIY workshops that enables a partner to send text reminders to rest in noisy environments; and the third is an IoT fridge-freezer that informs users of its load, notifying them of the best times for grocery shopping; P4 proposed an IoT screen that appears to display programming jokes but actually ensures the safety of elderly individuals at home; P5 developed a health monitor for cats that attaches to their bodies and enables health status monitoring; P6 designed an IoT rubbish bin that detects metal items within it, encouraging users to recycle and sell metal cans; P7 envisioned IoT hangers placed on oven handrails that detect temperatures and utilise the heat to dry tea towels.**

### 5.2.1.5 Reflections

**Co-speculating interactions through IoT transformation for pleasure-driven design**

Collaborating with HCI researchers has allowed me to adopt their perspective when considering the significance of IoT transformations in shaping interactions between humans and objects. Shifting the focus from design to HCI, I have explored not only the implications of IoT transformations for pleasure-driven design but also how these transformations influence and reshape the relationship between humans and networked objects. Compared to the broader scope of strategic design thinking, HCI perspectives tend to focus more specifically on facilitating new interactions between users and IoT products. In the workshop, equipped with various attachments, HCI researchers speculated on how analogue products could be transformed and what these interactions might entail following a pleasure-driven design approach. The concepts they proposed reflected how these relationships can be altered by specific interaction modalities. For example, in Activity 3, P2 envisioned how an IoT guitar could interpret its usage through data collected by movement and noise sensors and remind users to achieve their practice goals.

The HCI perspective provided insights into specific electronic components capable of collecting valuable data and enriching interactions between humans and IoT products, thereby facilitating pleasurable experiences. As a designer myself, I observed that the ideas generated by participants in Activity 2 were more expressive compared to those in the other two activities, largely due to the LED matrix. The concept of using an LED matrix to provide feedback to users from the perspective of an object offers intriguing possibilities. In contrast to the LCD screen on Attachment 3, which displays only numbers and text in very limited colours, the LED matrix offers a much broader range of RGB colours and can display customised patterns and animations. This approach allows for exploring how an object’s interpretation of data can influence users’ psychological needs. This aspect will be further tested in the subsequent co-speculation experiment. On the other hand, some inappropriate examples developed by the participants, such as monitoring elderly individuals who do not understand technology (P3’s idea in Activity 3) and attaching an IoT clamp to a cat (P4’s idea in Activity 3), have alerted me as a designer to consider ethical issues when designing experiences for IoT.

### Ambiguity as a resource for design and co-speculation

Ambiguity, as a resource for design and co-speculation, fostered creativity and novelty in pleasurable experience design concepts in Workshop 4 and provided a more flexible approach for transforming analogue products into IoT forms. The results demonstrated that even within the same design activity and using the same IoT attachment, the participants' ideas varied depending on different scenarios and products. As Gaver et al. (2003) have suggested, there are three tactics for employing ambiguity as a design resource: enhancing ambiguity of information, creating ambiguity of context, and provoking ambiguity of relationship. In designing the probes (three attachments) for co-speculation, these tactics were applied. While I designed the form factor of the three attachments, I deliberately did not specify which sensors could be embedded with them. This approach, using ambiguous representations to emphasise uncertainty, allowed HCI researchers to select the most appropriate sensor based on their expertise. In contrast to Workshop 3, where I assigned specific products to participants for designing pleasurable experiences through IoT transformations – potentially constraining the scenarios – Workshop 4 left both the scenario and the products to be transformed ambiguous. I placed a set of cards on the desk, depicting potential analogue products for transformation, and left the choice open to the participants. This arrangement encouraged a wealth of ideas for transformation scenarios. In each design task, I presented participants with a psychological need to fulfil, as the design objective. This led participants to explore questions such as: Whose psychological need would be fulfilled? Why is it important to fulfil these needs through an IoT transformation? What would the relationship between the users and the transformed IoT product be like if it fulfilled a psychological need? This ambiguity regarding relationships encouraged them to consider the personal significance of objects in their environment and to question their values and activities.

### Developing the idea for a co-speculation experiment

The ideas generated in Workshop 4 provided a solid foundation for the subsequent practice – a co-speculation experiment. In Workshop 4, participants created solutions to address three types of psychological needs: relatedness, stimulation and meaning. In Activity 1, aimed at fulfilling the need for relatedness, participants proposed various long-distance communication methods enabled by IoT transformations to connect users, including audio calls (P1), video calls (P3), text messages (P7), voice messages (P2) and light signals (P3 and P6). In

Activity 2, which focused on the psychological need for stimulation, the proposed interaction methods ranged from counterfactual interactions (P2, P5, and P7) and competitive elements (P3 and P4) to assigning tasks to users and linking products with bidirectional functions. In Activity 3, addressing the need for meaning, HCI researchers introduced ideas emphasising different ideologies, from facilitating recycling (P6) and saving energy (P3 and P7) to achieving personal goals (P1 and P2), caring for other creatures (P5) and assuming the role of another's guardian (P4). For the subsequent co-speculation experiment, I plan to design an artefact that serves as both a research product (Odom et al., 2016) and a technology probe (Hutchinson et al., 2003), focused on fulfilling a psychological need and evaluating it in real-world conditions. The construction and deployment of functional prototypes in real-world settings are crucial for subjecting them to user testing and obtaining more comprehensive feedback. This approach will explore the effects of pleasure-driven design methods and the transformations from analogue to IoT products on the future relationships between humans and networked objects. Finally, I chose relatedness as the design objective due to its strong link to the connectivity of IoT products (Kanis, Brinkman & Macredie, 2006). Drawing inspiration from P3's idea in Activity 1 (connecting people by caring for plants), I decided to develop the research product around the concept of a pair of partners jointly caring for plants. Nevertheless, interaction solely through a button as seen in Attachment 1 seemed overly simplistic, prompting me to incorporate an LED matrix (inspired by the participants' ideas about Attachment 2) to enrich the interactions. Additionally, I derived inspiration from P3's idea in Activity 2, which introduced a competitive element into the interactions.

**Limitations**

The HCI researchers participating in Workshop 4 were exclusively from a single institution (Open Lab, Newcastle University), which may have led to a homogeneous perspective. Engaging participants from a broader range of institutions could have diversified the insights and ideas generated during the workshop. While the IoT attachments in Workshop 4 facilitated idea generation, interaction with them was limited to touching the probes, and participants were required to articulate their ideas through sketches. Allowing participants to physically modify or construct these prototypes might have deepened their engagement and enriched the design process.

#### 5.2.1.6 Summary of Findings

Co-speculating pleasurable experiences with HCI researchers generated fruitful and appealing ideas that are worth testing with a developed research product in real-world settings. These ideas provided insights into specific electronic components and novel interactions for triggering pleasurable experiences. The attachments proved to be an effective method in Workshop 4 for transforming analogue products into IoT products for pleasure-driven design purposes, while hands-on physical tools were helpful for applying *the IoTT for PLEX Framework* during ideation. Additionally, ambiguity as a resource for design and co-speculation fostered creativity and novelty in pleasurable experience design concepts and could facilitate novel interactions. Most importantly, drawing upon elements from participants' ideas such as connecting people by caring for plants, using LED matrices as an attraction and introducing a competitive element into interactions, I designed my research product, *the CloudPlanter*, for the next Co-speculation Experiment.

### 5.2.2 Co-Speculation Experiment: Connecting through Living with *the CloudPlanters*

#### 5.2.2.1 Context

Drawing upon the findings from Workshop 4, I designed an IoT attachment to transform a planter into an IoT device to facilitate users' psychological need for relatedness. The IoT planter, named *the CloudPlanter*, serves as both a research product and a technology probe. It was distributed to a psychologist, three designers and their loved ones, who provided valuable feedback and co-speculated future possibilities. The experiment was conducted following Rogers and Marshall's *Research in the Wild* (RITW) framework (2017), as indicated in Figure 5.23. Dhelim et al.'s study (2021) posited that IoT products have surpassed personal computing in fostering collaboration and social interactions and facilitated more social relationships among IoT entities. The psychological need for relatedness (refer to Table 2.6) was chosen as the theoretical foundation for this research. This co-speculation experiment explored how IoT transformations affect the relationship between loved ones as well as the relationship between humans and networked objects in a real-world scenario.

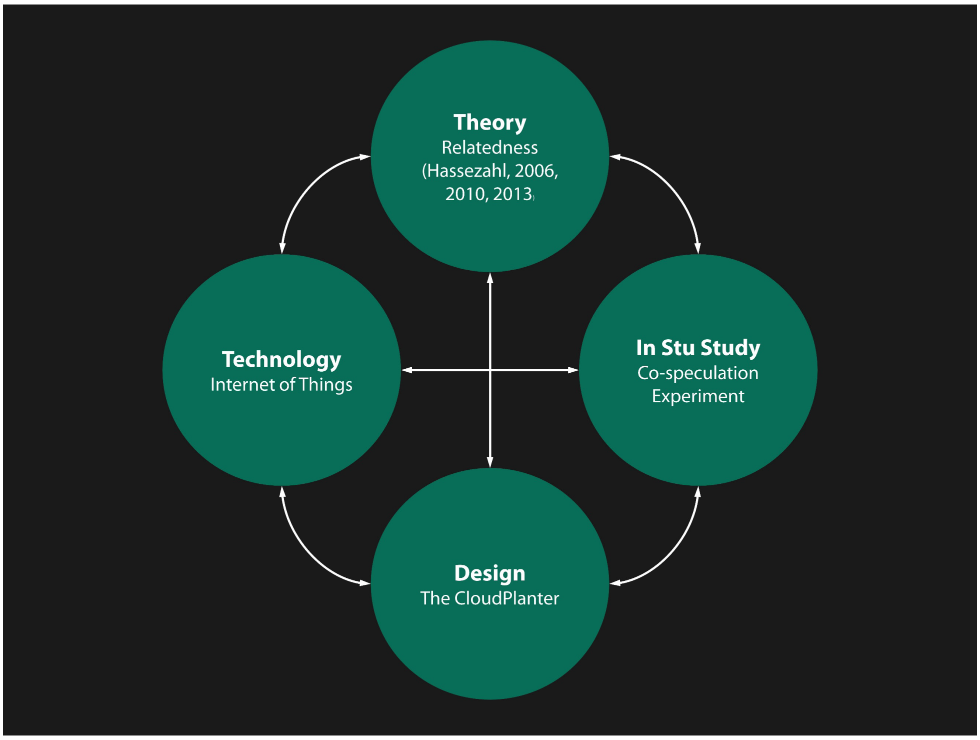


**Figure 5.23 *The CloudPlanter* experiment mapping on Rogers and Marshall's *Research in the Wild* (RITW) framework (2017:p.6).**

Before recruiting my participants, I obtained ethical approval from the RCA Ethics Committee. The original intention was to recruit two psychology researchers and to ask each share *the CloudPlanter* with a loved one, thereby forming two pairs. However, my efforts to recruit two psychologists were unsuccessful despite sending invitations to five universities in London with psychology departments or research centres. These professors and programme leaders either refused my request or did not respond to my invitation email. Only one psychologist (P1) agreed to participate in the experiment. The initial experiment was conducted with this psychologist and his daughter. Subsequently, designers and design researchers from RCA were invited to participate in the experiment. A participant recruitment questionnaire was created using Google Forms and distributed to all students within the School of Design at the RCA. The questionnaire inquired about their interest in caring for plants, their relationship with the person they intended to share *the CloudPlanter* with, and their motivation for participating in the experiment. Interested students completed the questionnaire. The participant selection process prioritised individuals with a strong interest in plant cultivation. Based on their responses, I selected three pairs of participants, each representing different relationship types. Alongside the pair involving the psychologist, the experiment comprised eight participants in total, thus forming four pairs. Table 5.3 presents information on the four groups of participants. Each pair consists of one male and one female participant. The participants were from six countries:

Canada, France, Italy, China, South Korea and Lithuania. 37.5% of participants (n=3) were aged between 26 and 35, and an equal proportion fell within the 35 to 45 age range. 12.5% of participants (n=1) were aged between 18 and 25, while another 12.5% were over 65 years old. As a token of appreciation, each participant was promised and received a £25 Amazon voucher upon completing the experiment.

**Table 5.3 Information of the participants in Co-speculation Experiment.**

| **Participants** | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| **Relationship** | Father and daughter living in the same area | | Colleagues who are in the same master's programme but not familiar with each other | | Close friends who were previous colleagues in the same undergraduate programme | | Partners who do not live together in the same city | |
| **Gender** | Male | Female | Female | Male | Female | Male | Female | Male |
| **Age group** | Over 65 | 36-45 | 26-35 | 26-35 | 18-25 | 26-35 | 36-45 | 36-45 |
| **Nationality** | Canadian | Canadian | Chinese | South Korean | French | Italian | Chinese | Lithuanian |
| **Role** | Psychologist | Bank clerk | Product designer | Product designer | Product designer | Product designer working in a plant shop | Healthcare design researcher | Unknown |

### 5.2.2.2 Method: Technology Probe

The method employed in this experiment includes co-speculation (introduced in *Section 5.2.1.2*) for collaborative speculation and envisioning potential future trajectories, interviews (introduced in *Section 5.1.2.2*) for collecting participants' feedback, as well as technology probes which collect users' data and test users' experiences.

Design probes are a method used to gather valuable and insightful data that is otherwise unknown, falling under the category of PD. In design research, a cultural probe provides toolkits (including cameras and diaries) to participants, enabling them to document their lives and behaviours (Gaver, Dunne & Pacenti, 1999). The essence of a cultural probe is to evoke inspiring responses from participants, which designers can observe to explore new possibilities (Sanders & Stappers, 2014). Design probes have evolved into various forms, such as empathy probes (Mattelmäki, 2005), technology probes (Hutchinson et al., 2003), urban probes (Paulos & Jenkins, 2005), domestic probes (Gaver et al., 2004) and value probes (Voida & Mynatt, 2005). These take forms ranging from traditional diaries to interactive artefacts and use data recording methods from self-documentation to automatic digital sensors. Technology probes are a form of probe embedded with digital sensors to collect data. They aim to achieve "the social science goal of collecting information about the use and the users of the technology in a real-world setting, the engineering goal of field-testing the technology and the design goal of inspiring users and designers to think of new kinds of technology to support their needs and desires" (Hutchinson et al., 2003:p.18). Hutchinson et al. argued that employing technology probes can engage users in the design process and generate unique ideas that may not be attainable through other methods, particularly in the context of complex social systems. This method has been extended to conduct ethnographic studies from a thing perspective, known as "thing ethnography", which aims to understand usage patterns and the complex relationships between humans and objects.

Two notable projects that applied technology probes to conduct thing ethnography are *ThingTank* (Giaccardi et al., 2016a, 2016b) and *Peekaboo Cam* (Cheng et al., 2019). The *ThingTank* study transformed domestic objects into technology probes by attaching digital sensors and autographs to them. Combining this data with participant interviews, the analysis revealed insights into the practices and personal experiences associated with making hot drinks from a "thing's perspective". Cheng et al.'s *Peekaboo Cam* explored an ecology shaped by daily objects in the home environment. They designed the Peekaboo camera, an IoT device in the form of a cuckoo clock that took time-lapse photos. Fieldwork showed that building trust through passive interactions was easier when users were unfamiliar with a product, while active interactions became preferable as users grew more familiar. The study demonstrated that trust in objects must be earned over time through interaction.

In this study, the designed IoT artefact, *the CloudPlanter,* served not only as a research product (Odom et al., 2016) for co-speculation but also as a technology probe to collect usage data. The usage data gathered from the probes helped formulate interview questions for the participants and provided valuable information when analysing the interview results.

#### 5.2.2.3 Research Design

The design of *the CloudPlanter* drew inspiration from the method applied in Workshop 4, which focused on using attachments to transform an analogue product into an IoT product. The inspiration was also drawn from design research projects that utilised the lighting of IoT products to facilitate communication between people such as *the Hole in Space* (Ylirisku et al., 2013), *the Messaging Kettle* (Ambe et al., 2017), *the Yo–Yo Machines* (Gaver et al., 2022a), *the Light*

*Touch* (Gaver & Gaver, 2023). I developed the IoT attachment named *the CloudPlanter Probe*, which can be affixed to a traditional planter to transform it into an IoT product (see Figure 5.24). *The CloudPlanter Probe* consists of various components including an LED matrix, a soil moisture sensor, a button and a Feather ESP32 development board with an integrated Wi-Fi module. It monitors the soil moisture level in the pot every minute, displays the readings on the LED matrix, and simultaneously uploads data to the cloud. Figure 5.25 illustrates an initial functional prototype of *the CloudPlanter Probe* during testing. Additional photos documenting the prototyping processes can be found in Appendix Q. Figure 5.26 showcases the program I developed in Arduino to realise *the CloudPlanter*'s functionality and interaction (the full Arduino codes can be found in Appendix R). Figure 5.27 presents the final prototype of *the CloudPlanter*.

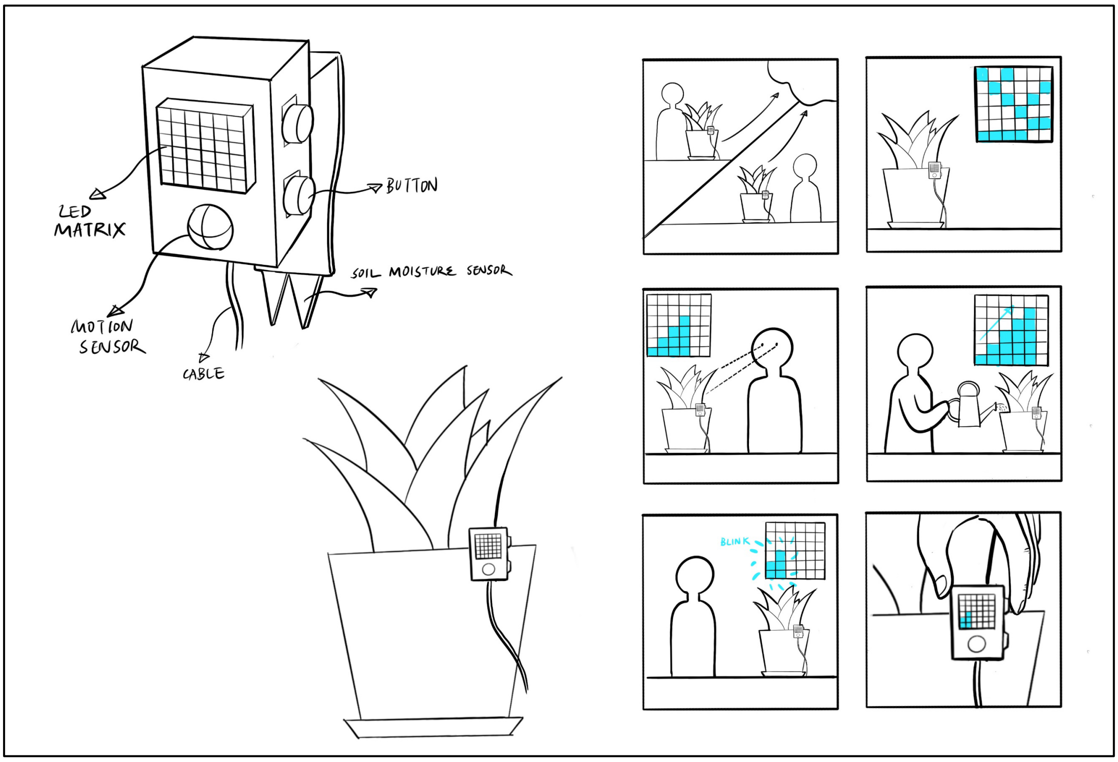


**Figure 5.24 The sketch of the initial concept of *the CloudPlanter.***

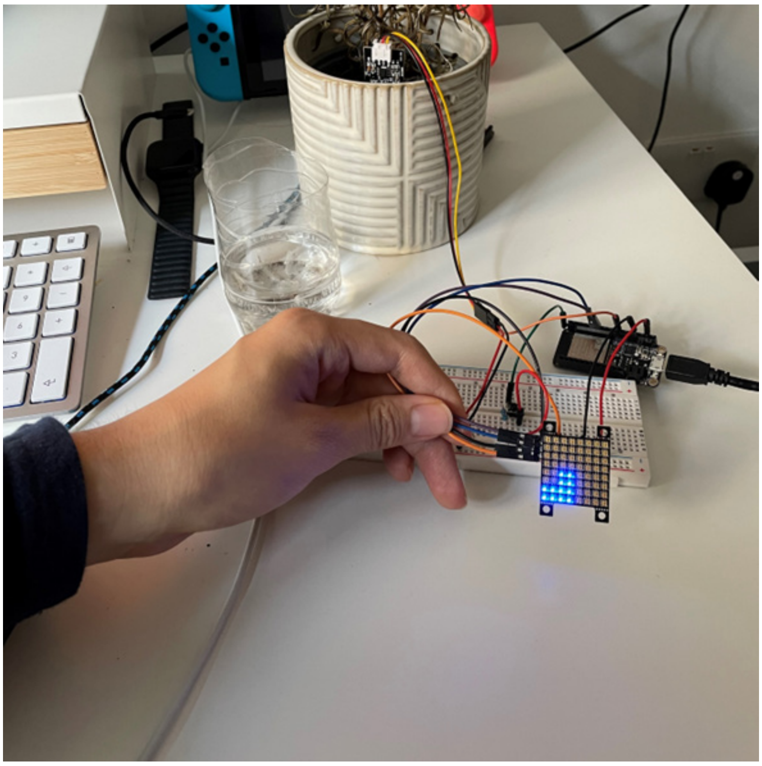

**Figure 5.25 An initial functional prototype of *the CloudPlanter Probe.***

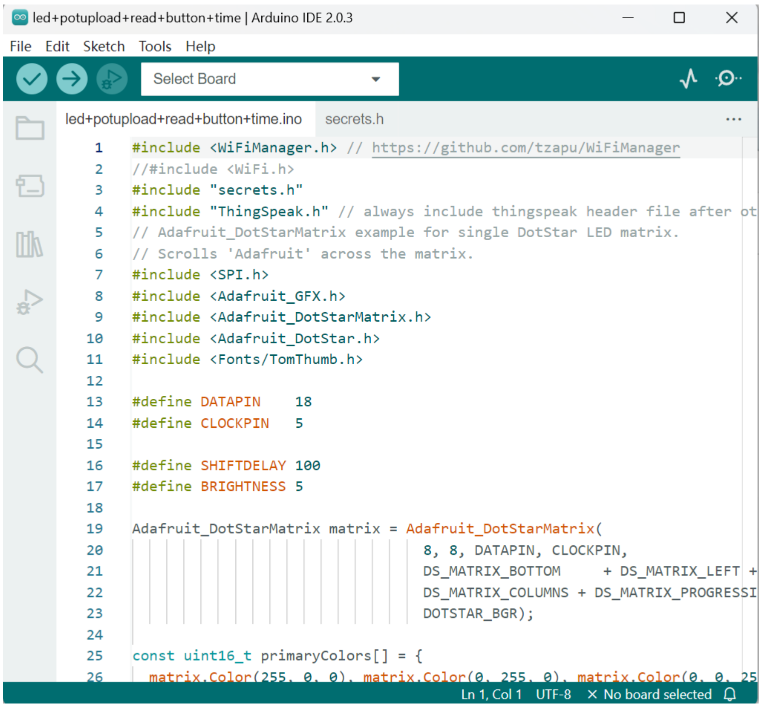


**Figure 5.26 The programming of *the CloudPlanter*'s functions and interactions using the Arduino IDE.**

**Figure 5.27 The final prototypes of *the CloudPlanter* – In this image, *the CloudPlanter* indicates that the soil moisture is at level 2.**

*The CloudPlanter* is engineered to upload real-time soil moisture data to the cloud service platform ThingSpeak, at one-minute intervals. User interactions with *the CloudPlanter* are intentionally designed to be simple and intuitive. The LED matrix on *the CloudPlanter Probe* continuously displays the soil moisture level in the user's own planter with a green pattern as shown in Figure 5.28. By pressing the button on the left side of the box-shaped part, the user can view the soil moisture level of the paired user's planter, which is displayed in a red pattern as presented in Figure 5.29. Moreover, *the CloudPlanter* notifies the user with an animation of blue patterns if the paired user has watered their plant within the last minute as shown in Figure 5.30.

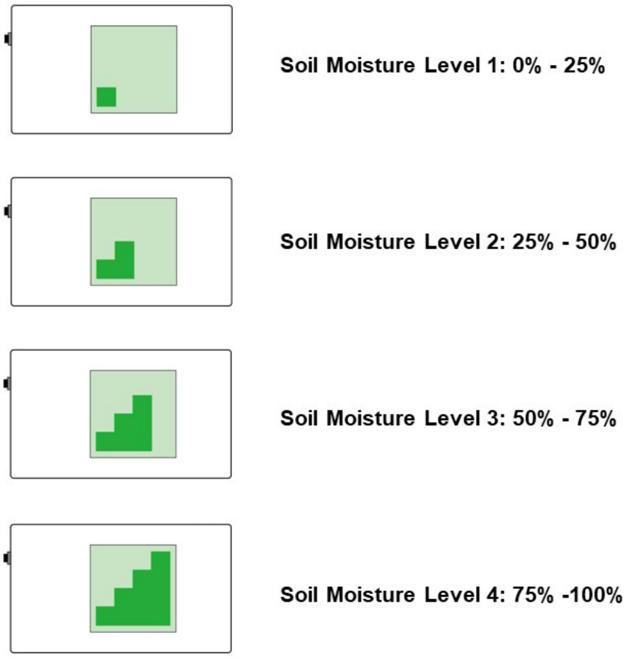


**Figure 5.28 The green pattern displaying the soil moisture in the user's *CloudPlanter*.**

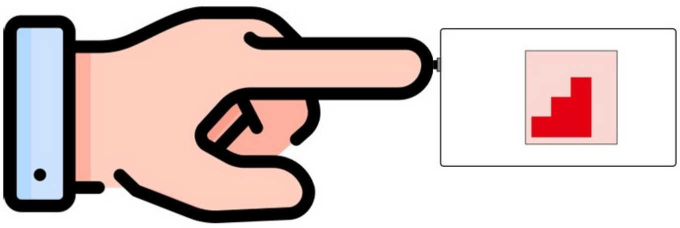

**Figure 5.29 Pressing the button displays the soil moisture level in the paired user's *CloudPlanter*.**

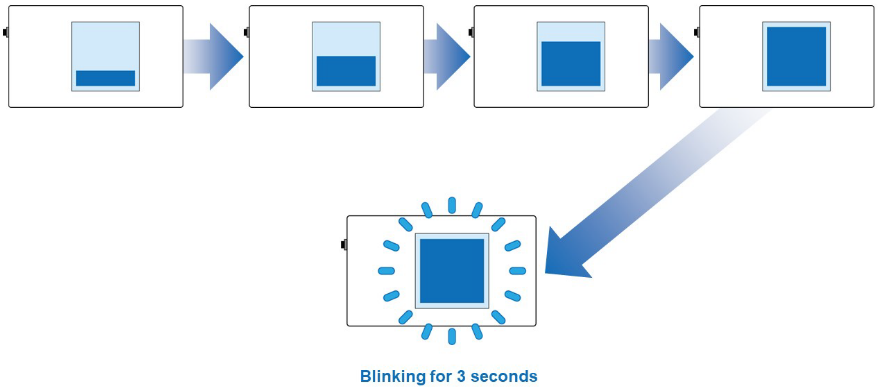


**Figure 5.30 The animation of blue patterns notifies the user when their paired partner has watered the plant within the last minute.**

The deployment of *the CloudPlanter* served two main purposes: 1) as a technology probe to gather valuable usage data from participants, and 2) as a research product to engage participants in co-speculation about the future relationship between networked objects and humans. In the experiment, each pair of participants who shared a close relationship but did not share the same living space were supplied with a pair of *the CloudPlanters*. This close relationship could be partners, family members or friends. Four pairs of participants lived with their *CloudPlanters* for 10 days. After completing the experiment, I conducted interviews with each participant to inquire about their experiences. Each interview consists of four sections: 1. setting up *the CloudPlanter*, 2. reporting on personal feelings, 3. sharing experiences and 4. evaluation and co-speculation. The participating psychologist was the first interviewed and offered insights based on his experiences with *the CloudPlanter*, particularly in terms of how these experiences connected to theories of psychological needs. He suggested using questionnaires to measure the experiences of other participants and he helped me in reviewing the interview and questionnaire questions from a psychological perspective. The three pairs of participants involving designers also filled out a questionnaire (see Appendix U for specific questions) regarding their experience with *the CloudPlanter*. The designers who participated in the experiment provided feedback from both the designer's and the user's perspectives in the interviews. Other participants only provided feedback from the user's perspective.

### 5.2.2.4 Key Results

**Participants' Information and Questionnaire Feedback**

Participants' feedback in the questionnaire is detailed in Table 5.4. Regarding their overall experience with *the CloudPlanter*, 12.5% of participants (n=1) reported it as extremely pleasurable; 25% (n=2) found it very pleasurable; and 25% (n=2) considered it slightly pleasurable. However, 37.5% (n=3) viewed the experience as neutral. Using the SD scale, the mean overall experience rating for *the CloudPlanter* was 1.125, which approximates the level of "slightly pleasurable" (1). Additionally, 25% of participants (n=2) reported in the questionnaire that their sense of relatedness to their partner improved after the experiment, with one moving from "slightly unconnected" to "slightly connected", and another from "slightly connected" to "very connected". In terms of *CloudPlanter*'s influence on their relationships, 12.5% of participants (n=1) perceived it as extremely positive, 12.5% (n=1) as very positive, and 50% (n=4) as slightly positive. However, 12.5% (n=1) considered the impact neutral.

**Table 5.4 Information of the participants and their questionnaire feedback in Co-speculation Experiment**

| ***Participants*** | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 |
|---|---|---|---|---|---|---|---|---|
| ***Relationship*** | Father and daughter living in the same area | | Colleagues who are in the same master's programme but not familiar with each other | | Close friends who were previous colleagues in the same undergraduate programme | | Partners who do not live together in the same city | |
| ***Gender*** | Male | Female | Female | Male | Female | Male | Female | Male |
| ***Age group*** | Over 65 | 36-45 | 26-35 | 26-35 | 18-25 | 26-35 | 36-45 | 36-45 |
| ***Nationality*** | Canadian | Canadian | Chinese | South Korean | French | Italian | Chinese | Lithuanian |
| ***Role*** | Psychologist | Bank clerk | Product designer | Product designer | Product designer | Product designer working in a plant shop | Healthcare design researcher | Unknown |
| ***Overall experience*** | Very pleasurable | Very pleasurable | Slightly pleasurable | Neutral | Extremely pleasurable | Slightly pleasurable | Neutral | Neutral |
| ***Relatedness before using the CloudPlanter*** | Very connected | Very connected | Slightly unconnected | Slightly connected | Very unconnected | Slightly connected | Neutral | Very connected |
| ***Relatedness after using the CloudPlanter*** | Very connected | Very connected | Slightly connected | Slightly connected | Very connected | Very connected | Neutral | Slightly connected |
| ***The influence on relationship*** | Slightly positive | Slightly positive | Very positive | Slightly positive | Extremely positive | Slightly positive | Neutral | Neutral |

### Interview Feedback: Setting up *the CloudPlanter*

The placements of *the CloudPlanter* at participants' residences and the data uploaded to the cloud are presented in Figure 5.31 and Figure 5.32. I will discuss these data alongside interview feedback. Participants typically placed their *CloudPlanters* in noticeable locations – on a window (P2, P8), a table (P3, P6), a work desk (P1, P4) and a bedside table (P3) – without relocating them during the study. P3, P5 and P6 set their devices in their bedrooms; P1 in his workroom; P4 in his living room. However, P7 and P8 moved their units out of their bedrooms due to poor Wi-Fi connectivity and overly bright LED lights. Despite the winter season in London offering limited sunlight and predominantly cloudy weather, all plants received some sunlight exposure. Five participants had no issues setting up *the CloudPlanter* and comprehending its functionality. P6, however, struggled with connectivity using an Android phone due to the instructions being tailored for iPhone Wi-Fi setups. He resolved this with the help from P5. Both P7 and P8 experienced frequent data upload disruptions from weak Wi-Fi signals and were advised to relocate their *CloudPlanters* nearer to their routers. Additionally, renovation activities in P7's kitchen led to physical disruptions of her device, reflected in the data upload graphs for P7 and P8.

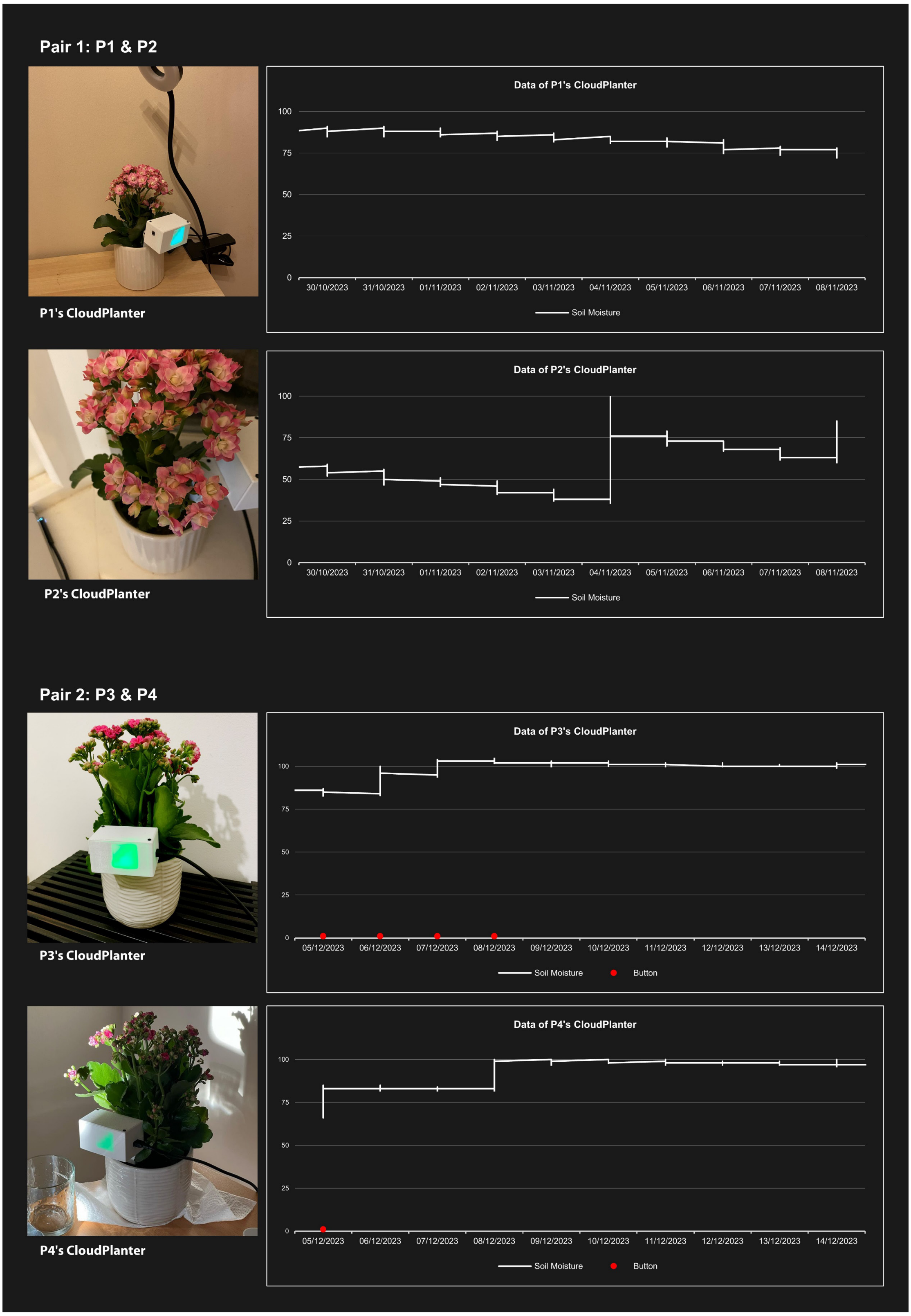


**Figure 5.31 Photos and data of Pairs 1 and 2's *CloudPlanter*.**

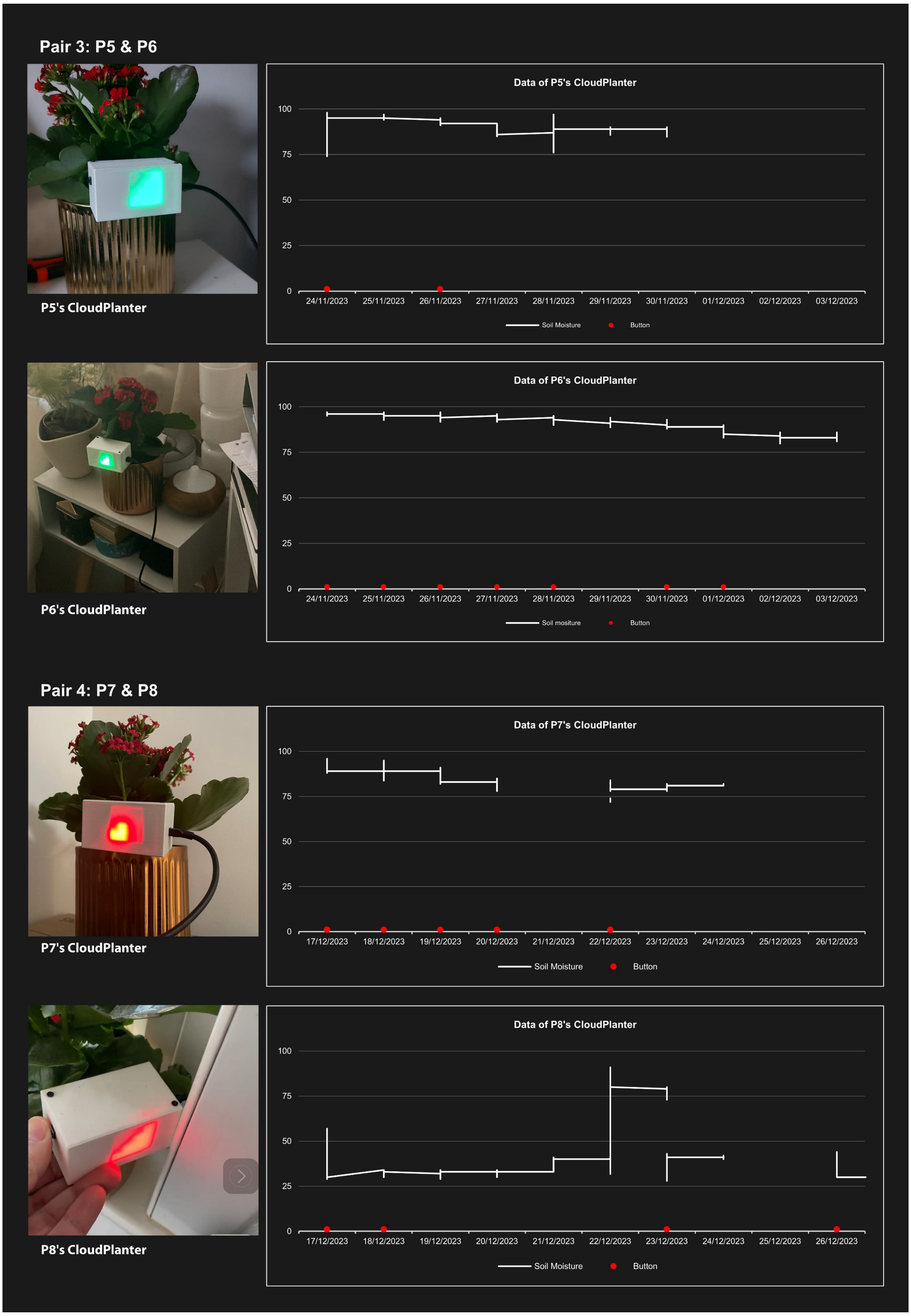


**Figure 5.32 Photos and data of Pairs 3 and 4's *CloudPlanter*.**

**Interview Feedback: Personal Experiences**

In the Co-speculation Experiment, participants reported various watering habits and checked soil moisture differently. P1 reported that he watered his plant three times, while P2 reported she watered hers twice. However, according to the data uploaded to the cloud, the soil moisture in P1's *CloudPlanter* did not have any significant increase during the experiment and P2's soil moisture increased twice. P3 reported that she initially watered her plant daily, then reduced this to once every one or two days after realising the soil moisture was full. The data indicated that P3 overwatered her plant, which caused the sensor reading to exceed its maximum, reaching 103%. This led to a fault in the *CloudPlanter*, where the LED pattern disappeared for three days. Accordingly, when her partner P4 pressed the button, the soil moisture level was not displayed during this period. In the interview, P3 explained her frequent watering: "Although the indicator light was always at the full level, I was afraid the plant would become very dry. I feel that when the heating is on, my skin gets very dry, and I thought the plant might experience the same, so I watered it in advance." P4 reported that he watered the plant daily, but the data only reflected one significant soil moisture level increase during the experiment. In the interviews, both P5 and P6 claimed they did not water their plants during the experiment. However, P6 reported that P5 had mentioned watering her plant, which is consistent with the data showing a significant increase in terms of the soil moisture. P8 claimed that he watered his plant twice, and he made his decision based on previous experience rather than the soil moisture level displayed on the LED matrix, believing plants need watering only once a week in winter. P7 mentioned she watered her plant once or twice a week, as she did not feel the urge to water it after seeing the moisture level displayed on the *CloudPlanter*.

Participants showed varying levels of engagement with the device's connectivity features to check on others' plant moisture levels during the experiment, which introduced social dynamics into plant care. P1 never pressed the button to check P2's soil moisture level. Living in the same area as her daughter P2, he preferred visiting her home every three days to check the soil moisture in person. After checking, P1 felt reassured. P2 felt she had established an unusual human connection: "It has that human connection piece in there. But somehow you feel like, oh, he's not there, so I'm kind of communicating with a plant. Living being, yes, but it's almost like it's more than just a machine. I would say it's more like a conduit for me." Both attempted to check each other's soil moisture levels by pressing the button several times. However, after P3 overwatered her plant, P4 could no longer see P3's soil moisture level, and his button presses were not uploaded to the cloud in this period. P5 checked P6's soil moisture by pressing the button 4-5 times and found the act of "spying" enjoyable. P6, on the other hand, pressed the button daily, except on one or two occasions, hoping to find P5's plant in need of water as a pretext for contact. He described a happy incident on the experiment's last day: "She told me that the experiment was done and then I press the button, and I saw that she didn't have water. So I texted her. I was like: 'oh shame!' She told me that she deactivated it." Initially, P8's *CloudPlanter* frequently failed to uploading data due to poor Wi-Fi connectivity. I contacted P7 and instructed her to tell P8 to unplug and re-plug the device. After each reconnection, P7 checked P8's soil moisture, leading to negative experiences for her. In the interview, P7 expressed frustration: "when I asked him to unplug and re-plug, he said he did, but there was never any change on my end. I always thought there would be some change, and I got really angry, feeling like he was fooling me, saying he unplugged it when he actually hadn't." P8 maintained a neutral feeling after checking soil moisture, reporting a lack of interest in plants.

Participants shared that their most pleasurable moments with *the CloudPlanter* included seeing the plant survive (P1), competing with their partner over the soil moisture level (P2), interacting with its LED features (P3, P4), the device facilitating social connections (P5, P6) and seeing animation showing that the partner had watered the plant after being prompted (P7). Notably, P5 and P6 highlighted how the device fostered personal interactions. P5 particularly valued the face-to-face meetings *the CloudPlanter* facilitated, stating: "the nicest thing is that I could be there for my friend. Because he's working and I'm having a lot of my master's coursework, we don't have too much time to catch up. Because of the plant, I feel like we talked more." P8 did not experience a "most pleasurable" moment and suggested that more anthropomorphic patterns on the LED matrix would have made the product more appealing. However, participants' most unpleasurable experiences with *the CloudPlanter* included overly bright LEDs disturbing them during the night (P3, P5), the constant need for a power supply making the setup inconvenient (P6) and frequent Wi-Fi disconnections that led to frustration (P7). The comparison with traditional planters revealed a mixed response. Some users appreciated the technological enhancements for providing easy moisture monitoring (P1, P5, P7) and enriching user experiences through interactive feedback (P3, P4, P7). Conversely, others missed the tactile interaction with soil, found the technological features intrusive or excessive (P6, P8). P6 expressed his perspective: "I don't want to relate plants with technology, with high tech… when people see a lot of technology in nature, it feels too contrasting, too sci-fi. So we should adopt it in a more organic way. Not just the shape, but the concept. So basically fewer screens. I'd get rid of the screen."

**Interview Feedback: Connecting Experiences**

During the experiment, all participants were based in London, close enough to visit each other within an hour's journey by public transport. P1 and P2, as well as P7 and P8, maintained their regular contact, with *the CloudPlanter* providing new topics for discussion. P3 and P4 increased their interaction by exchanging contact details as a result of the study. P5 and P6 also increased their interaction frequency, using the planter as a catalyst for daily phone conversations and occasional in-person meetings. However, P7 and P8 did not alter their interaction frequency despite taking part in the experiment. Participants' discussions of *the CloudPlanter* varied: some (P3, P4, P5, P6) referred to it more often than others (P1, P2, P7, P8).

Specifically, P1 and P2 discussed *the CloudPlanter* three times: initially about setting it up, then to remind each other to water the plants, and finally about concluding the experiment. P3 and P4, despite working on their final term assessments, discussed the device approximately eight times. They reported that their conversations focused exclusively on the device due to their busy coursework schedules, leaving little time for more casual topics. P5 and P6 conversed about it five to six times, discussing not only plant watering and their experiences with plant care but also their design projects and personal lives. Interestingly, their online discussions led to an in-person meetup for drinks. P7 and P8 discussed *the CloudPlanter* three to four times. They met in person during the experiment, but their meetings were not influenced by the device. Their discussions were primarily about network issues and triggering the animation by watering the plant, but they did not engage in deeper conversations. Notably, only P3 and P7 observed the blue animation triggered by watering which indicates engagement with the device's features, while others missed these moments either because their partners did not water the plants (P2, P4, P6) or because they were not in front of the plants at the corresponding time (P1, P5, P8).

Participants reported different emotional responses after discussing the device with their partners. P1 felt at ease, while P2 noticed no change in her emotions. P3 felt nervous due to her limited English proficiency but felt pleased when successfully communicating with P4, who had a mild positive emotional response. P5 and P6 both felt happier because *the CloudPlanter* rekindled their communication. P7 was happy when her partner watered the plant at her request, but her trust later diminished due to uncertainties about his actions. In contrast, P8 remained emotionally neutral throughout the experiment. Regarding the impact on their relationships, P1 noted *the CloudPlanter* simply added a new topic to conversations, whereas P2 felt it strengthened their connection. P3 found that it facilitated more natural interactions with P4, who suggested more emotive interactions could be integrated into the device. P5 used *the CloudPlanter* as a reminder to reach out to P6 during busy times and believed it brought them closer. P1-P6 all reported feeling more connected to their partners after using *the CloudPlanter.* P7's relationship suffered due to doubts about her partner's participation, while P8 felt the experiment was too short to have a significant impact on their relationship and suggested a longer duration for future studies.

**Interview Feedback: Evaluation and Co-speculation**

In the final section of the interview, all participants evaluated *the CloudPlanter* and speculated on the future relationship between human beings and IoT from the user's perspective. P1 contributed insights from a psychological perspective, while P3-P7 offered insights from a designer's perspective.

From a psychological perspective, P1 posited that *the CloudPlanter* could satisfy the human need for relatedness by facilitating human-to-plant and human-to-human connections. He suggested that forming relationships with plants could be simpler than with other entities such as animals. P1 described *the CloudPlanter* experience as pleasurable due to its role in making plant care information more accessible and understandable, thereby improving user engagement and satisfaction. He also viewed *the CloudPlanter* as a potential therapeutic tool, arguing, "As I'm a psychologist, I can use this kind of thing as a means to promote clients to have more relationships with substances and also more relationships with people." Moreover, P1 noted that the vouchers offered as rewards for participating in the study served as motivational elements. He recommended that experience designers apply task-centred theory to give users simple tasks that foster feelings of accomplishment. P1 also advocated for the use of cognitive behavioural theory to introduce tangible, practical elements that shift mindsets and highlight benefits. For evaluating product pleasurability, he advised developing a questionnaire that avoids psychological jargon and technical terms, thus ensuring it is accessible and not burdensome to respondents.

All participants expressed a continued interest in using *the CloudPlanter* and offered suggestions for its improvement. While P2 envisioned sharing the device with a friend overseas, P3 stated she would use it even if not connected to another person. P3, P4, P5, P6, P7 and P8 desired more diverse interactions. Suggestions included integrating *the CloudPlanter* Probe directly into the planter (P6) and enhancing the LED matrix with emotive faces (P3, P4, P5, P8) and additional animations (P5, P7, P8). P3 and P5 also proposed a feature to switch off the LED matrix at night, and P8 recommended a motion sensor to activate the display.

Participants reflected on the influence of IoT products on future emotional experiences. For instance, P3 found pleasure in interacting with smart products during boredom; P4 noted a social trend in South Korea where IoT could provide companionship; P5 emphasised the need for IoT products to seamlessly integrate into the environment; and P7 envisioned IoT devices as "digital pets" providing companionship. However, P6 expressed privacy concerns and expected control over the data shared between devices, stating, "I like the communication between devices when I am the one communicating. But I wouldn't like if the devices communicate between each other to serve a business using my data. I should be in control of myself or my life." P8 speculated that while distractions from IoT products can lead to depression, their iterations could bring happiness.

Participants expressed diverse views on the future relationship between IoT and humans. P3 preferred simple IoT devices and doubted their significant impact on enhancing communication, while P4 saw potential in IoT as companions and secretaries, though not as replacements for pets. P5 discussed IoT's scalability and its capacity to convert qualitative interactions into meaningful data and stressed the importance of maintaining physical human connections. P6 was optimistic about IoT and AI's future role but expressed concerns about these technologies surpassing human capabilities and potential addiction issues. He speculated, "I guess we will be the chimpanzees, and they will be the humans in a way, if I don't understand that technology, IoT technology." P7 noted the proliferation of IoT, like smart speakers, and anticipated more interconnected devices, whereas P8 envisioned a highly automated future that might eliminate the need for human involvement in activities like plant care.

Regarding promoting communication and shortening distance, P4 found that IoT facilitated his interactions despite generally being an introverted person. He explained, "I'm the person who doesn't make contact that much. So it would have been really difficult for me to do this kind of experiment. But still, I managed to do all kinds of interactions." However, P5 cautioned against over-reliance on digital connections over physical presence. She elaborated, "we need to remember that the first point of contact is in person. Nowadays, young people think that they don't need to meet in person, because they already have been on their phone with the person." P6 believed IoT's impact on relationships depended on specific contexts, such as situations where people are unable to meet physically or are in conflict. P7 thought IoT could enhance patience and attentiveness to emotional expressions. Conversely, P8 was sceptical about IoT's role in bringing people physically closer and questioned the improvement of life quality under such technological influence. He stated, "I think it might bring people closer, but in a sense, not physically closer."

#### 5.2.2.5 Reflections

**Co-speculating future object-human relationships through living with *the CloudPlanter***

The co-speculation experiment further addressed sub-RQ3 "How do pleasure-driven experience design and the transformations from analogue to IoT products influence future relationships between human beings and networked objects?" *The CloudPlanter* was designed to fulfil the psychological need for relatedness by encouraging two people to care for plants together from a distance. The results indicated that most participants experienced pleasure and felt more connected during the experiment. Thus, *the CloudPlanter* successfully achieved its design objectives. Although *the CloudPlanter* effectively fulfilled the psychological need for relatedness, it may not have done so in the way designers initially anticipated. It was intriguing to observe the differences between anticipated and actual interactions, as well as between expected and real experiences. For instance, P1 bypassed the button intended for connecting two people and instead chose to visit his daughter's home in person to check the soil moisture, a scenario not foreseen in *the CloudPlanter*'s design. P5's most pleasurable moment, an in-person meeting with P6 triggered by *the CloudPlanter*, was also unanticipated. Additionally, *the CloudPlanter* was more effective for individuals who were not familiar with each other or had become less connected. For pairs like P1 and P2, and P7 and P8, which shared a closer relationship, *the CloudPlanter*'s impact was less pronounced compared to the groups of P3 and P4, and P5 and P6. Based on the results of the experiment, I tend to agree with Hassenzahl's (2018:p.26) view that experience can be designed, and that designers can mediate experience by various elements, although they cannot completely manipulate it. Specifically, designers can shape the pleasurable experience of IoT products by fulfilling a specific psychological need through mediating interactions.

When speculating on the future relationship between humans and networked objects, participants expressed concerns about how humans might relate to connected objects. P5 speculated that connections fostered by IoT products might lead to fewer in-person meetings. P6 worried that IoT products would become smarter than humans, making it difficult for humans to compete with them. P3 and P7 mentioned that IoT products with higher levels of agency could become human companions, potentially taking on roles similar to pets. The experiment also revealed a tension between the simplicity and complexity of IoT product interactions with humans. While P6 and P7 desired more interactions from *the CloudPlanter*, P3 preferred simpler operations and P5 emphasised the need for IoT products to be seamless. When analogue products are transformed into IoT products, the complexity of the technology increases. However, as Norman argued, designers always strive to create interfaces and interactions as simple and understandable as possible (2013), but this can hide the data in the IoT system and raise concerns regarding privacy and data security. Therefore, while focusing on momentary pleasure, designers also need to build meaningful interpretations for the data presented to users. This facilitates an understanding of the long-term positive impacts of IoT products, thus enhancing eudaimonic qualities (Mekler & Hornbæk, 2016).

In the experiment, the emerging relationship between humans and non-human entities was noteworthy. This encompassed not only interactions between users and *the CloudPlanters* but also between humans and plants. Interestingly, P1, P2, P5 and P7 all mentioned in their interviews that *the CloudPlanter* made caring for plants easier. P1 also expressed a growing interest in plant cultivation. However, the questionnaire results did not show an increase in the participants' interest in plant care after the experiment. The multiple interactions (Table 5.1) mentioned in *the IoTT for PLEX Framework* included objects and humans as entities of interactions but not plants or animals. A future research direction could focus on how IoT products facilitate interactions between humans and other creatures.

The engagement of a psychologist (P1) in the experiment provided valuable psychological insights for pleasure-driven design through IoT transformations. The psychologist recommended task-centred theory (Reid et al., 1980; Ramos & Stetson, 2022) and cognitive behavioural theory (Beck, 2020; Butler et al., 2006) to help designers meet users' psychological needs. These theories have the potential to help design researchers integrate new psychological concepts into the design domain and in further developing iterations of *the IoTT for PLEX Framework*. Future design research could investigate how these theories impact pleasure-driven design through research-through-design projects. Notably, the psychologist posited that IoT products could have therapeutic applications. It would be interesting to examine how designers' thinking and methods can contribute to IoT products' impact on psychological therapy (Vahdat-Nejad et al., 2022). Therefore, *the CloudPlanter* experiment highlights the potential for engaging psychologists in design research not only as participants but also in planning.

**Testing *the IoTT for PLEX Framework* through an in-the-wild study**

*The CloudPlanter* is designed following *the IoTT for PLEX Framework* and the co-speculation experiment was conducted following Rogers and Marshall's research in the wild (RITW) framework (2017:p.6). In this study, I played the role of the designer in creating *the CloudPlanter* with the goal of fulfilling the psychological need for relatedness. The results of the experiment showed that three pairs of participants felt their psychological need for relatedness was satisfied, demonstrating the effectiveness of *the IoTT for PLEX Framework* in guiding designers to conduct pleasure-driven design through IoT transformations. Although the previous study (Berger et al., 2019) began to explore the connections between emotional and sensory qualities of interaction in IoT design, using Hassenzahl's earlier works (Diefenbach, Lenz & Hassenzahl, 2013; Lenz, Diefenbach & Hassenzahl, 2014) as their foundation, they did not incorporate Hassenzahl's theory of psychological needs (Hassenzahl, 2010; Hassenzahl, Diefenbach & Göritz, 2010; Hassenzahl et al., 2015) as a starting point. In contrast, *the IoTT for PLEX Framework* uses Jordan's four types of pleasure (2002) and Hassenzahl et al.'s psychological needs (2010; 2010; 2015) as its foundation, connecting these theories with different types of interactions within an IoT network. *The CloudPlanter* tested these interactions for fulfilling the psychological need for relatedness, designed using Hassenzahl's framework, in real-world scenarios and demonstrated the value of *the IoTT for PLEX Framework* and its method of designing pleasurable experiences by fulfilling psychological needs through IoT transformations.

**Designing pleasurable experiences by fulfilling the psychological need for relatedness through IoT transformations**

*The CloudPlanter* served as an exemplar for designing pleasurable experiences by addressing the psychological need for relatedness through IoT transformations. This co-speculation experiment identified three key factors influencing the effectiveness of fulfilling psychological needs using a specific IoT product. First, the pre-existing relationship between paired participants influenced the effectiveness of the CloudPlanters. The CloudPlanters were most effective for P5 and P6 (Group 3), former colleagues and friends who had lost contact after completing their studies. Similarly, it improved relatedness between the father and daughter in Group 1 and the unfamiliar colleagues (P3 and P4) in Group 2. However, in Group 4, the couple (P7 and P8) reported no increase in relatedness, as their relationship was already very close. These findings suggest that IoT connectivity is particularly beneficial for relationships constrained by time and space.

Second, the frequency of prior communication between paired participants influenced the device's effectiveness. In Groups 2 and 3, where participants expressed a desire to communicate more frequently, *the CloudPlanter* facilitated meaningful interactions. In contrast, for Group 1 (father and daughter) and Group 4 (couple) who already communicated regularly, the device had limited impact on increasing interaction frequency. Third, the need for an object serving as a conversational trigger emerged as a critical factor, highlighting the emotional value of physical objects. For relationships requiring a prompt to initiate dialogue, *the CloudPlanter*'s interactions proved effective. *The CloudPlanters* were designed to motivate paired users to care for a plant remotely, encouraging dialogue and fulfilling the need for relatedness. Groups 1, 2, and 3 used *the CloudPlanters* to initiate discussions about plant care. Interestingly, P1 (Group 1) bypassed the IoT functionality, opting to check the soil moisture in person, yet the device still managed to facilitate meaningful dialogue. In contrast, P7 and P8 (Group 4) primarily discussed technical issues related to the device rather than plant care, reflecting a mismatch between their needs and *the CloudPlanter*'s intended purpose.

***The CloudPlanter* as a research product**

As a research product (Odom et al., 2016) rather than a commercial one, *the CloudPlanter*'s primary aim is to provide inspirational insights for designers, design researchers and HCI researchers. It successfully tested whether psychological needs could be met through pleasure-driven design through IoT transformations, facilitated by its simple and direct interactions. In designing *the CloudPlanter*, I intentionally focused on relatedness and avoided overly complex interactions and functions to facilitate a simple behaviour instead – watering a plant. This allows participants to connect through *the CloudPlanter* and potentially initiate other forms of communication. Most functions worked during the experiment, despite extreme cases such as P3 over-watering the plant and P7 and P8 experiencing poor network connectivity. The most significant issue was *the CloudPlanter*'s occasional disconnections from the network, an outcome that was anticipated given the device's deployment across eight households with different, unpredictable network configurations.

Participants suggested improvements during interviews, such as adding animations, incorporating multiple, more complex functions and improving the aesthetic style. These factors are more critical for evolving *the CloudPlanter* into a commercial product. Notably, they recommended features that anthropomorphise *the CloudPlanter*. However, in its design, I aimed to avoid blurring the lines between human and machine by embodying Sterling's (2005) concept of "biot" and instead focused on the concept of "spimes". Spimes are more closely aligned with the current status of IoT, and Sterling predicted that the age of spimes would arrive by 2030. In contrast, the biot, representing a highly advanced AI with a physical form almost indistinguishable from human beings, would emerge much later. From a design researcher's perspective, to improve *the CloudPlanter* as a research tool, I consider P6's suggestion of replacing the power cable with a battery valuable. This would offer greater convenience for participants to position *the CloudPlanter* for optimal Wi-Fi signal and engagement. It was also worth noting that *the CloudPlanter* could only detect soil moisture levels up to 100% and could not determine if the plant was over-watered. The inclusion of this feature might have enhanced the participants' overall experience.

**Limitations**

In the Co-speculation Experiment, recruitment was limited to a single psychologist. Engaging more professionals from the field of psychology could have provided a richer array of psychological perspectives. Moreover, *the CloudPlanter* Experiment was conducted during the winter, a period when soil moisture decreases more slowly. Conducting the experiment in summer, when plants typically need more frequent watering, could amplify the participants' interactions and communications via *the CloudPlanters*. While connectivity issues presented challenges, they also led to positive and insightful observations about the potential effectiveness of this approach in delivering pleasurable experiences if technological reliability improves and technical issues are resolved. However, it is considerably challenging for an early-stage prototype to avoid technical problems, especially with very limited testing time. Additionally, there was a communication issue regarding device usage; half of the participants watered the plants independently of the displayed moisture levels, indicating that the experiment's introduction requires refinement in future iterations.

#### 5.2.2.6 Summary of Findings

The Co-speculation Experiment demonstrated that pleasure-driven design through IoT transformations has the potential to improve future relationships between humans and networked objects by fulfilling psychological needs. However, some participants from design backgrounds expressed concerns about the negative impact of IoT products "smartness" on humans. Testing *the CloudPlanter* in an in-the-wild scenario showed that the previously developed *IoTT for PLEX Framework* can support designers in creating pleasurable experiences by applying IoT transformations to a specific analogue product (a planter, in this case). The findings identified three critical factors for fulfilling paired users' psychological needs through an IoT product: pre-existing relationships, prior communication between users and the need for an object to act as a conversational trigger. Additionally, the performance of *the CloudPlanter* in the Co-speculation Experiment suggested that a research product with simple interactions is effective for achieving the study's aim. Finally, the study revealed that users of a research product might not fully understand its research purpose and may have expectations aligned more closely with those of a commercial product.

# 6. Discussion

## 6.1 Synthesis of Practice Reflections

### 6.1.1 Designing Pleasurable Experiences Through IoT Transformations

In Stage 1: *setting an initial direction*, the comparison between smartwatches and wristwatches contributed insights for designing pleasurable experiences through IoT transformations. Firstly, Survey 2 demonstrated the application of UX metrics within a questionnaire to assist designers in understanding the differences in pleasurable experiences between an IoT product and its analogue form. Contrary to Survey 1, which compared the experiences of two products across separate user groups, Survey 2 conducted the comparison within the same user group. This method produced significant results and effectively highlighted the differences in pleasurable experiences between an IoT product and its analogue form. Secondly, Stage 1 highlighted the importance of considering an IoT product's hedonic qualities for pleasure-driven design. Survey 2 revealed that smartwatches have advantages in eliciting pleasure and meeting psychological needs because their features extend beyond the traditional wristwatch's function of telling the time. This suggests that the hedonic qualities of smartwatches are key to pleasurable experiences which align with Hassenzahl et al.'s (2015) findings that psychological needs correlate more strongly with hedonic than pragmatic qualities. Thirdly, for products like wristwatches, which possess strong luxury and decorative attributes, designers must account for aesthetics in the IoT transformation process. Survey 2 indicated that while wristwatches' strengths lay in build quality, appearance and a sense of luxury, these strengths diminish in smartwatches, along with the pleasure derived from such aspects. Martin's study (2002) posited that wristwatches often symbolise identity and social status, attributes that disappear when transformed into smartwatches. However, this principle may not apply to everyday domestic IoT products such as smart kettles, heaters or fridges, where luxury is less apparent. This was evidenced in Workshops 3 and 4, and *the CloudPlanter* Experiment. Lastly, Stage 1 revealed that existing theories of experience remain valuable for designing pleasurable experiences with emerging IoT products. Surveys 1 and 2 demonstrated that Jordan's four types of pleasure (2002) and Hassenzahl et al.'s six psychological needs (2010; 2015) could be recognised in the pleasurable experiences of smartwatches, which provided a foundation for the subsequently developed *IoTT for PLEX Framework*.

In Stage 2: *generating a new method*, results from Workshops 1 and 2 indicated that the existing pleasure-driven design approaches have limitations in guiding designers to design pleasurable experiences through IoT transformations. Jordan's hierarchy of consumer needs (functionality, usability and pleasure) and Hassenzahl's three levels of goals (motor goals, do goals and be goals) did not offer recommendations for considering all types of interactions within an IoT system, which ignores the uniqueness of IoT products. Another insufficiency identified in these two frameworks is their failure to encourage designers to reflect on the agency and the role of specific IoT products. Cila et al. (2017) and Giaccardi et al. (2016b, 2016a) have shown that each networked thing occupies its position within the ecosystems they form, suggesting designers should account for the characteristics of each object in the experiences they are designing. Surveys 1 and 2, along with Workshops 3 and 4, adopted Hassenzahl, Burmester and Koller's (2021) suggestion to critically question technology through models, processes, metrics and principles. These approaches help identify the essential elements that a method for designing experiences through IoT transformations should involve. In summary, an adapted method should guide designers to: 1) ascertain whether pleasurable experiences should be prioritised, 2) understand how immaterial resources (i.e., algorithms, software, and data) can shape experiences, 3) consider multiple interactions of IoT products and 4) account for the characteristics, including the agency and role of each element in the network.

Therefore, I developed the novel *IoTT for PLEX Framework,* which emphasises the four factors mentioned above as a method to support designers in creating pleasurable experiences through IoT transformations. This framework integrates pleasure-driven design theories (Jordan, 2002; Hassenzahl, 2010; Desmet & Hassenzahl, 2012; Hassenzahl et al., 2013, 2015) with data sensing, agency, roles and interactions brought by IoT experiences. Workshop 3, which tested this framework in supporting the creativity of IoT experiences, uncovered the opportunities and possibilities offered by IoT product transformation for experience design. Its streamlined structure fostered innovative and disruptive thinking. Participants responded positively towards a tool that supports the design of innovative and pleasurable experiences through transformations from analogue products to IoT products. As a design and HCI researcher, creating an effective

IoT experience creativity tool like *the IoTT for PLEX Framework* that helps designers envision pleasurable experiences is not merely a matter of implementing pleasure-driven design theory; it also requires careful design. Designers should be encouraged to explore the connection between experience design and IoT transformation, informed by the requisite design knowledge and key considerations. Drawing from my experience with *the IoTT for PLEX Framework*, I proposed the following design implications for the development of new IoT creativity-supporting tools in pleasure-driven design:

1) **Paying attention to experiences derived from non-utilitarian qualities of products:** The tool should prioritise the creation of pleasurable experiences, broadening the focus from solely product functionalities to the emotional and psychological experience-related aspects.
2) **Providing prompts for design understanding and drawing experience design knowledge from other disciplines (e.g., psychology)**: The tool should offer helpful prompts and resources that aid designers in better understanding user experiences and integrating insights from related fields to enhance the overall design process.
3) **Leveraging analogue product augmentation as an experience design strategy**: The transformation from analogue products to IoT products involves augmenting analogue products, enabling designers to envision innovative experiences distinct from interactions with analogue products.
4) **Comprising guidelines for managing agency and designing detailed IoT interactions:** As IoT products possess greater agency and interconnectedness, the tool should include guidelines to help designers navigate and manage the complexities of interactions within the IoT system.
5) **Including evaluation criteria for designers to self-evaluate their ideas:** The tool should incorporate evaluation criteria to enable designers to critically assess their ideas and ensure they align with the intended pleasurable experience outcomes.

In Stage 3: *speculating on the future*, Workshop 4 highlighted how human-object relationships can be mediated through interactions facilitated by IoT transformations. It provided specific ways of implementing electronic components like buttons, the LED matrix and the LCD screen into IoT products to shape interactions in a pleasure-driven design context. Additionally, the workshop revealed ambiguity as a design resource (Gaver, Beaver & Benford, 2003) for envisioning innovative pleasurable experiences through IoT transformations. Generally, ambiguity acts as a stimulus that encourages designers to broaden the diversity of their ideas. Ambiguity of information prompted them to consider which analogue products are more suitable for transformation into IoT products. Ambiguity of context inspired imaginations regarding various scenarios where pleasure might be elicited. Ambiguity of relationship stimulated considerations about the integration of different devices within an IoT network at home. Moreover, Workshops 3 and 4 demonstrated that augmentation (Kuniavsky, 2010) is a successful strategy for designing pleasurable experiences through IoT products. The ideas generated in Workshop 4 and the design of *the CloudPlanter* demonstrated the effectiveness of IoT attachment as a method for transforming analogue products into IoT products. This strategy offers designers a clear and straightforward way to understand and depict the differences before and after these transformations.

*The CloudPlanter* experiment indicated that while designers can design for pleasurable experiences, they cannot fully manipulate these experiences. However, they can target a psychological need – such as relatedness – and construct experiences around it through IoT transformations. Although participants might not perceive the experience as intended by the designer, they can build their meaningful narratives with the IoT product, potentially fostering a harmonious human-object relationship in the future and facilitating human flourishing (Ryan & Deci, 2001; Desmet & Pohlmeyer, 2013). Moreover, *the CloudPlanter* experiment brought attention to two psychological theories – task-centred theory (Reid et al., 1980; Ramos & Stetson, 2022) and cognitive behavioural theory (Beck, 2020; Butler et al., 2006) – which have the potential to benefit designers in creating pleasurable experiences through IoT transformations. The findings from Workshops 2, 3 and 4 collectively validate Hassenzahl's (2018) view that experiences can be intentionally designed, and that designers have the capability to shape pleasurable experiences by satisfying psychological needs. Moreover, these results challenge Krajewski's (2017) arguments that the psychological needs identified by Sheldon et al. (2001) and subsequently adapted by Hassenzahl (2010) are incompatible with IoT features. Indeed, my workshops and experiments demonstrated that at least some of these needs – such as relatedness, stimulation and meaning – can be addressed through IoT transformations.

### 6.1.2 The Mutual Relationship between Pleasure-Driven Design and IoT Transformations

The reflections from my design practices uncovered a mutual relationship between pleasure-driven design and the transformations from analogue to IoT products. In addressing the core research question of this research, "What new possibilities for pleasure-driven experience design are suggested by the transformations from analogue products into IoT products?", it is this mutual relationship that reveals these new possibilities. Five stimuli that IoT transformations can contribute to pleasurable experiences have been identified:

**IoT transformations can enable designers to better elicit different types of pleasure and fulfil psychological needs through unique IoT features.** The results from Survey 2 quantitatively demonstrated that smartwatches and traditional wristwatches elicit three types of pleasure and fulfil five psychological needs differently. This highlights the distinctions between an IoT product and its analogue form. The ideas generated in Workshops 1-4 illustrated that IoT features could be viewed as augments (Kuniavsky, 2010) of analogue products for eliciting pleasure and meeting psychological needs. The roles of objects and their agency (Cila et al., 2017) and interactions (Table 5.1) outlined in *the IoTT for PLEX Framework* offer designers specific strategies for eliciting pleasure and satisfying psychological needs.

**IoT transformations can enable designers to recontextualise a pleasurable experience pattern in innovative ways.** The inclusion of various types of sensors and multiple interactions, which the transformation facilitates, allows an IoT product to evoke subjective meanings that its analogue form cannot achieve. For instance, Group 3's idea in Workshop 3, P1, P2, P3 and P4's ideas in Activity 1 of Workshop 3 and *the CloudPlanter* experiment conceptualised experiences that facilitated distant communication. These innovative concepts illustrate how IoT products can serve not only as utilitarian tools but also as mediums to foster experiences of connection. This exemplifies how the newly designed interactions can "provoke people to reflect on the way electronic products shape their experience of everyday life" (Dunne, 2006:p.100).

**IoT transformations can enable designers to utilise immaterial resources to create pleasurable experiences.** Drawing upon Sterling's notion of "spime" (2005), IoT products are seen as physical manifestations of digital services.

Balancing digital and physical materials is necessary when creating pleasurable experiences through the transformation from analogue to IoT products. Speed and Oberlander (2016) pointed out that designers can be informed by the opportunities embedded in data to support and enrich human values. It is noteworthy that digital services facilitated by immaterial resources often enable new possibilities for pleasurable experiences. In Workshops 1 and 2, all participants initiated new software when designing novel pleasurable experiences for smartwatches. In Workshops 3 and 4, where mundane domestic products were transformed into IoT devices, it was the programme running in the background controlling the sensors and introducing new features. During the co-speculation experiment, although users interacted with a physical planter, their connections and the fulfilment of their psychological need for relatedness were mediated through data shared on the cloud.

**IoT transformations can enable new methods for pleasure-driven design, such as *the IoTT for PLEX Framework* developed in this research**. This framework is grounded in established pleasure-driven design theories (Jordan, 2002; Hassenzahl, 2010; Desmet & Hassenzahl, 2012; Hassenzahl et al., 2013, 2015) and integrates them with IoT transformations. By intertwining these existing pleasure-driven design approaches with the agency and interactions characteristic of IoT products, a new design method emerges. The evaluation of *the IoTT for PLEX Framework* during Workshop 3 demonstrated that such innovative methods could effectively support designers in conceptualising pleasurable experiences through IoT transformations. Additionally, it provides design and HCI researchers with a valuable research tool to investigate pleasure-driven design in the context of transitioning from analogue to IoT products.

**IoT transformations can inspire designers to conceive a wide range of interactions in experience design, from simple one-to-one interactions between people and objects to complex ones involving multiple objects or multiple people.** In the *IoTT for PLEX Framework*, Table 5.1 lists 16 types of interactions within an IoT system. During Workshops 1-4, participants initially focused on how a single analogue object could facilitate interactions with another object or a person when transformed into an IoT form. As their ideas evolved, they considered interactions involving multiple objects and people, such as groups of objects tracking the quality of weight training or communities sharing smoothie recipes. The Co-speculation Experiment explored how two connected *CloudPlanters* could mediate human-to-human interactions. Most of the interactions involved in this research were between single entities (either people or objects). Future studies should explore more complex scenarios involving multiple objects and multiple people.

Furthermore, not only do IoT transformations facilitate pleasure-driven design, but the pleasure-driven approach also helps designers transform analogue products into IoT forms more effectively. I propose three potential benefits of applying pleasure-driven design theories to the development of IoT products from their analogue counterparts based on the findings of the studies within this research:

**Pleasure-driven design can deepen designers' understanding agency of IoT products.** Design and HCI studies (Wakkary et al., 2017, 2018; Hauser et al., 2018) have always called for a harmonious relationship between humans and smart products balanced by agency. The agency of IoT products can impact humans' pleasurable experiences during interactions. However, the relationship between the level of agency and the pleasurability of a product can be complicated. For example, Surveys 1 and 2 showed that even though smartwatches have a higher level of agency than traditional wristwatches, they did not overcome the traditional wristwatches in fulfilling all psychological needs. The concept from Group 4 (wardrobe for autonomy) in Workshop 3 suggested that sometimes the pleasurable experience of a product is not positively correlated with its level of agency. Thus, to design pleasurable experiences effectively, designers need to gain a deeper understanding of IoT products' agency.

**Pleasure-driven design can emphasise meaningful purposes for IoT transformation.** In Workshops 3 and 4, the pleasurable experience patterns summarised based on participants' personal experiences reflect an inherent human impulse towards pursuing pleasure, as highlighted in philosophical perspectives (Borchert, 2005; Hardie, 1980; Mill, 2009). Beginning with a pleasurable experience pattern, IoT transformations act as a tool to transfer this pattern into diverse scenarios. As a result, products developed under this method possess a clear purpose in contributing to pleasurable experiences. The subjective meaning and social value provided by IoT products render them more sustainable (Ambe et al., 2017), avoiding the creation of meaningless smart products that may be discarded by users, as critiqued in existing studies (Lazar et al., 2015; Lindley, Coulton & Cooper, 2017).

**Pleasure-driven design can encourage designers to look beyond the pragmatic qualities of IoT products.** In line with pleasure-driven design theories (Desmet & Hassenzahl, 2012; Hassenzahl, Diefenbach & Göritz, 2010; Hassenzahl et al., 2013), if designers seek to evoke psychological pleasure through a product, they must focus on the hedonic qualities and extend beyond its basic functions. The concepts developed in Workshops 3 and 4 and the design of *the CloudPlanter* demonstrate how the transformation of analogue products into IoT forms can transcend basic functionalities to provide pleasurable experiences. As a result, employing pleasure-driven methods can enhance the hedonic quality of an IoT product, aligning with the trend in HCI that shifts focus from pragmatic to hedonic experiences (Diefenbach, Kolb & Hassenzahl, 2014).

## 6.2 Meanings of Pleasure in IoT Transformations

The studies conducted in this research have revealed the varied meanings of pleasure in IoT transformations. My understanding of these meanings has dynamically evolved alongside the progress of the research. In the literature review, I examined the lexical meaning of pleasure and its notion in philosophical and psychological discussions, exploring how these theories have been introduced into experience design. From a psychological perspective, pleasure is defined as a state conducive to acceptance (Frijda, 2009), which positively evaluates sensations, objects, actions, people and events (Fredrickson, 2001). It is not categorised as a type of emotion in established emotion models (Plutchik, 1980; Russell, 2003), but this state can be associated with various positive emotions such as anticipation, joy, trust and surprise. Psychological theories classify pleasure into different categories (Tiger, 2000; Frijda, 2017), which have profoundly influenced the development of experience design frameworks in hierarchical structures (Jordan, 2002; Norman, 2005b; Desmet & Hekkert, 2007; Hassenzahl, 2010). Design researchers link pleasure to hedonic quality and assess whether a product delivers pleasure to users by determining whether it elicits a specific type of pleasure (Jordan, 2002), fulfils a psychological need (Hassenzahl, 2010) or evokes a positive emotion (Desmet, 2012). Drawing on these existing theories, I have defined "pleasurable experiences" in this thesis as the positive momentary experiences elicited from hedonic qualities and examined how "pleasure" manifests within the specific context of IoT transformations.

Initially, Jordan's four types of pleasure (2002) and Hassenzahl's six psychological needs (2010; 2010; 2015) served as standards for measuring pleasure in IoT transformations, assuming that a product must either elicit a specific type of pleasure or fulfil a psychological need to provide pleasurable experiences. Survey 2 highlighted the differences in pleasurable experiences between smartwatches and traditional wristwatches, representing the transformation from analogue to IoT products in terms of these types of pleasure and psychological needs. From these observations, I came to understand pleasure in IoT transformations as the capability to elicit different types of pleasure or fulfil different psychological needs compared to analogue products, or to elicit the same type of pleasure or fulfil the same psychological need in a different way through its IoT features. Moreover, Jordan's and Hassenzahl's theories proved effective for understanding pleasure associated with IoT transformations.

In Stage 2, participants in Workshops 1 and 2 perceived the same type of pleasure from the same IoT product – smartwatches – differently across various scenarios. This emphasised that pleasure associated with IoT products heavily relies on the context of use, with narrative playing a crucial role in shaping these experiences. The essence of pleasure in IoT products lies not in their augmented hardware and advanced functionalities but in their ability to make sense of data and position users within contexts where they can elicit positive experiences. Through the development of *the IoTT for PLEX Framework*, pleasure has been reimagined by leveraging existing pleasurable experience patterns facilitated by IoT transformations. The framework emphasises the importance of placing experience over product features, which aligns with the principles of aesthetic interactions (Petersen et al., 2004; Lim et al., 2007; Petersen, Hallnäs & Jacob, 2008; Lenz, Diefenbach & Hassenzahl, 2014). Pleasure should not be regarded merely as one of many aspects of experience design but can also serve as the focal point of design efforts, as I propose in the concept of pleasure-driven design. This perspective directly connects subjective emotional responses to the roles of objects, the agency of objects and the types of interactions in IoT transformations, which can all be considered as stimuli for acceptance tuning (Frijda, 2009), leading to pleasure. The results from Workshop 3, which called for an evaluation method for designed pleasurable experience concepts, highlighted that the real measure of an IoT product's pleasure is the user's perceived experience in real-world scenarios. This pleasure can only be effectively evaluated through user testing.

During Stage 2, the COVID-19 pandemic also influenced my understanding of pleasure in the context of IoT transformations. As mentioned in Chapter 4, while conducting Workshops 1 and 2, I had to work remotely from home, and participant recruitment, as well as in-person activities, were constrained by city lockdowns, travel restrictions and safety concerns. These limitations influenced my selection of psychological needs for Workshop 4 and the Co-speculation Experiment. Combining my own experience with the challenges faced by many researchers during the COVID-19 pandemic such as isolation from loved ones, the loss of family members, a lack of stimulation in work and research and a broader rethinking of life's meaning. I identified relatedness, stimulation and meaning from Hassenzahl's six psychological needs as particularly relevant. These needs were selected for exploration in the context of IoT transformations due to their apparent influence on pleasure during this period. Additionally, the isolated experiences of the pandemic further reinforced my decision to focus on designing for relatedness in the Co-speculation Experiment.

In Stage 3, the Co-speculation Experiment demonstrated that fulfilling users' psychological needs for relatedness leads to pleasure, as evidenced by participants who reported an enhanced sense of connection after the experiment. When co-speculating the future relationship between humans and network objects with participants, they expressed concerns about the long-term impacts of IoT on their lives. This research initially defined pleasurable experiences primarily involving momentary pleasure elicited through IoT transformations, excluding long-term well-being. However, after completing the design practices, I recognised that long-term well-being is a crucial aspect of pleasure in IoT transformations and should not be ignored by designers. Survey 2 indicated that battery life is a significant disadvantage of smartwatches compared to traditional wristwatches, with users seeking greater convenience for long-term usage. Furthermore, with the growing emphasis on sustainability in design, there is a rising expectation for IoT products to have longer lifespans and be easily repairable (Pilling et al., 2023; Lechelt, Gorkovenko & Speed, 2024). Thus, including eudaimonic elements (Müller, Mekler & Opwis, 2015; Mekler & Hornbæk, 2016) in pleasure-driven design for IoT products should be considered a vital future direction in design and HCI research. Emphasising the eudaimonic quality of experience not only improves immediate pleasure but also aligns with broader goals of sustainability and well-being in experience design (Desmet & Pohlmeyer, 2013; Hassenzahl, Burmester & Koller, 2021) and enriches the overall value and appeal of IoT transformations.

Additionally, P6's critique of *the CloudPlanter*'s form factor highlighted how the pleasure derived from aesthetics changes significantly when analogue products are transformed into IoT forms. The aesthetics of appearance play an important role in emotional experiences at the visceral level in traditional industrial design (Norman, 2005b). For example, Philippe Starck's Juicy Salif is a product designed to provoke dialogues between users, as claimed by the designer himself. However, the emphasis on aesthetic appeal diminishes in IoT products as the transformation process requires the integration of various industrial components and a compromise on the principle "form follows function (Papanek, 1985)" (Rowland et al., 2015:p.222). This shift is reflected in the results of Surveys 1 and 2 which showed that traditional wristwatches satisfied users' needs for luxury better than smartwatches. This transformation suggests that the aesthetic pleasure of IoT products not only focuses on appearance but is also embedded within interactions, actions and perceptions. Different types of pleasure and psychological needs might be elicited and fulfilled through different layers of aesthetics of IoT products. Given the example of *the CloudPlanter* designed for my Co-speculation Experiment, the tactile satisfaction of pressing a button could evoke physio-pleasure; the connectivity facilitated by *the CloudPlanter* could meet the psychological need for relatedness; and the sense of achievement from completing the experiment and sustaining the plant's life could satisfy the need for competence.

As design knowledge is provisional (Gaver, 2012), the meaning of pleasure in IoT transformations can be dynamic and shaped by the implementation of new technology in this scenario. Upon reviewing the concepts developed in the workshops after completing all design practices, I observed AI algorithms emerging as a feature in some of the pleasurable experience ideas from participants (e.g., Groups 1 and 4's ideas in Workshop 4 and P1's ideas in Activity 2 in Workshop 5). AI was utilised for making recommendations and promoting decision-making during the interactions between a user and an IoT product. All of these ideas share a common method: they use AI to empower an IoT product with a higher level of agency. However, as Hassenzahl, Burmester and Koller (2021) pointed out, the autonomous, provocative, complex and anthropomorphised features of AI can introduce challenges in experience design, potentially undermining users' psychological needs for competence and autonomy. While AI was not initially a core focus of this research, its integration with IoT transformations highlights its potential to add complexity to pleasurable experiences. Exploring the explicit influence of AI on various types of pleasure within IoT transformations can be posited as a direction for future research.

## 6.3 The Emergent Methodology

This research developed an emergent methodology (detailed in Figure 6.1) and planned methods in response to each study based on the findings of the previous one and situational needs. The methodology encouraged emergence by adopting strategies from Gaver et al. (2022b:p.522) including "consider anomalies to be inspirations" and "seek idiosyncratic examples of design settings", which designed the studies around issues and challenges. By integrating quantitative methods in the early stages, qualitative approaches in later phases and an integration of both as needed, the research adopted a mixed methods approach that underpinned its emergent methodology to comprehensively address the research questions. In Stage 1, positivist quantitative research methods were employed to identify significant statistical differences in pleasurable experiences between an IoT product and its analogue form, using UX metrics to convert experiences into numerical data for easy comparison. Once these differences were identified, the methods transitioned from quantitative to qualitative in Stage 2, which aimed to explore how these differences could support designers in conducting pleasure-driven design through IoT transformations. This transition was due to the limitation of quantitative methods, which reveal the phenomena statistically but do not examine design theories in practice (Bryman, 2012:p.179). From Stage 2, qualitative methods under the category of PD, including workshops, interviews, material speculation, co-speculation and technology probes, were selected for their effectiveness in supporting mutual learning and engaging diverse participants. Workshops 1 and 2 employed workshops and design probes to examine the challenges designers might face in this process and to test existing pleasure-driven design approaches.

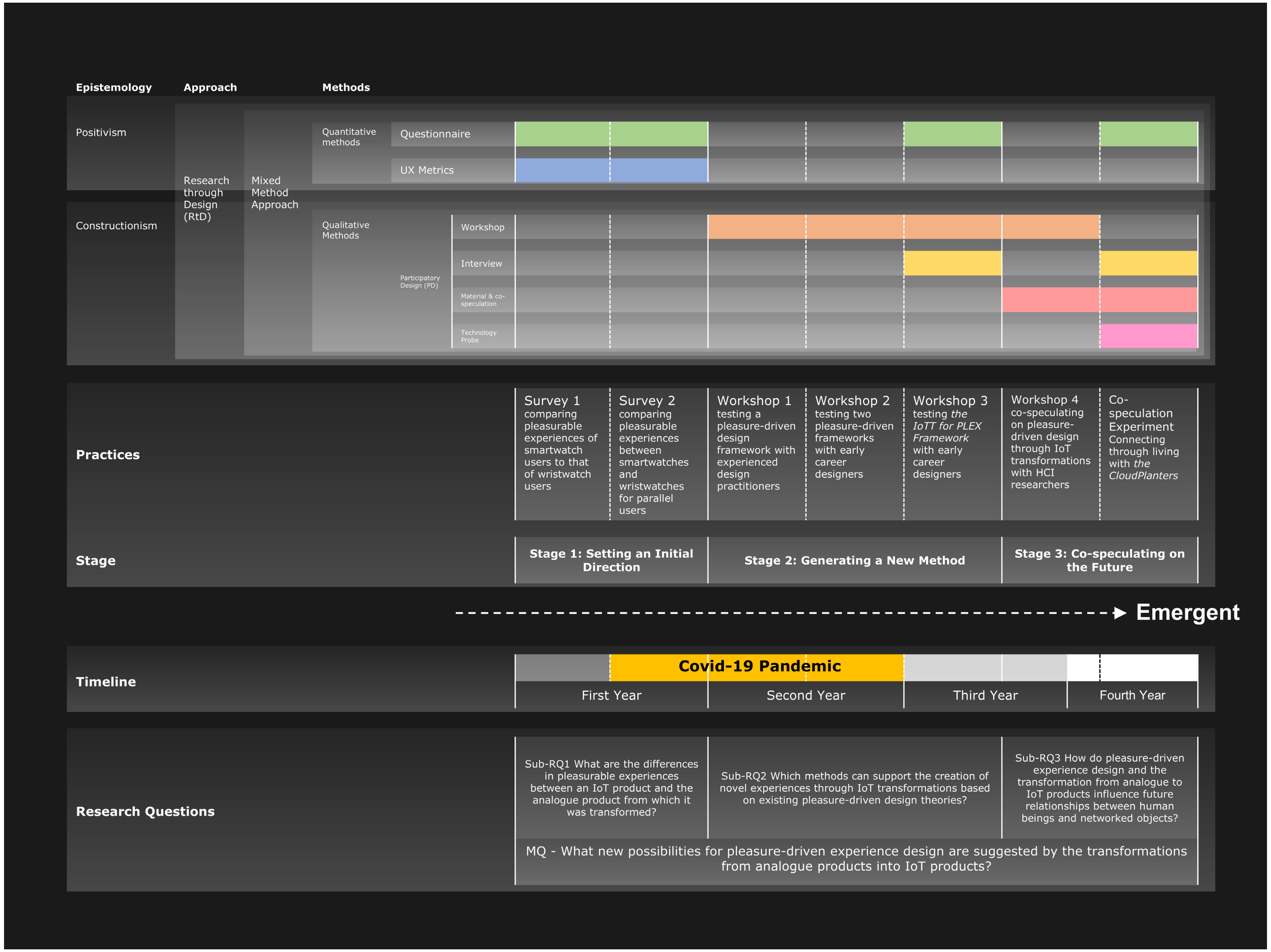


**Figure 6.1 An overview of the methodology.**

The external environment also emerged as a significant factor that influenced method selection during the research. Workshops 1 and 2 were conducted during the COVID-19 pandemic, which required the development of an online mode using Miro and Zoom. Notably, Sanders et al.'s framework for categorising PD tools (2010) did not suggest any specific tool or technique for online scenarios that involved acting, enacting and playing. However, in Workshop 2, role-playing was successfully conducted on Zoom, demonstrating the potential for online platforms to adopt more tools and techniques from this framework, thereby supporting Bannon et al.'s (2018) suggestion for combining PD with other methods. Building upon these initial findings, *the IoTT for PLEX Framework* was developed to support designers in envisioning pleasurable experiences through IoT transformations. This framework was tested in Workshop 3 to assess its strengths and limitations. Workshop 3 employed mixed methods comprising questionnaires and interviews. The reintroduction of quantitative research gathered participants' overall feedback on the new framework effectively and helped me to select potential participants for interviews.

The outcomes of Workshop 3 demonstrated the need for physical prototypes and hands-on activities in pleasure-driven design through IoT transformations. Therefore, moving into Stage 3, physical prototypes (three IoT attachments) were designed for Workshop 4, applying the co-material speculation method (Wakkary et al., 2015). Given the involvement of a cross-disciplinary group – including HCI researchers – co-speculation (Wakkary et al., 2018) proved to be an ideal PD method, allowing both participants and myself to share insights effectively. Findings from all four workshops emphasised the necessity of functioning prototypes to evaluate pleasurable experiences in real-world scenarios. Thus, the technology probe method, designed both to test the project and to understand users' patterns through data collection, was selected for conducting a co-speculation experiment as an in-the-wild study (Rogers & Marshall, 2017). To gather participants' views on the future relationship between humans and networked objects, the study also incorporated mixed methods including technology probe, co-speculation, questionnaire and interviews, which collected both quantitative and qualitative data to comprehensively understand the experience patterns of *the CloudPlanter*. In the co-speculation experiment, I shifted roles between being a designer, creating the technology probe – *the CloudPlanter*, and being a researcher, conducting the experiment and interviews. This adaptation illustrates that a researcher's role must flexibly respond to the identified needs in emergent design research.

This dynamic approach of developing an emergent methodology allowed me, as a design researcher, to adapt my methods based on the findings from different stages of the research. In design research involving humans and networked objects, where inconsistencies and unpredictable results are always emergent, it can be challenging to establish and consistently apply a fixed methodology from the beginning. An emergent methodology offered me greater flexibility compared to a pre-designed methodology in research-through-design practices, allowing me to modify my methods in response to different people, settings, ideas, and things. This approach reflects the importance of emergent elements in practice-based design research, as emphasised in existing literature (Krogh, Markussen & Bang, 2015; Redström, 2011; Hansen et al., 2020). The shift was particularly important when transitioning from a positivist quantitative approach to a constructivist qualitative approach, resulting in the selection of multiple methods. Initially, only quantitative research was employed for the exploratory study, and participatory design was considered a potential method for later stages. This approach aligns with Gaver et al.'s (2022b:p.524) emergence strategy that recognises starting points as provisional. Throughout the research, I tried to value agility and responsiveness (ibid.:p.254) as my understanding of pleasure in IoT transformations evolved in response to new events, insights, design ideas and material influences. The research was narrated as a journey, reflecting on each study's outcomes and how their emergent elements influenced subsequent research designs. This emergent methodology presented in the thesis provides a model for design research in related fields on how to encourage, manage, narrate and assess emergence effectively.

# 7. Conclusions

## 7.1 Revisiting Research Questions

Through practices across three stages, I have explored new possibilities for pleasure-driven design facilitated by IoT transformations. I have investigated how pleasure-driven design theory can support designers in creating novel experiences through IoT features. I have explored new methods for designers and researchers to envision and evaluate pleasurability with IoT products. The findings answered three sub-research questions:

Sub-RQ 1:

> What are the differences between the pleasurable experiences of an IoT product and the analogue product from which it was transformed?

An IoT product and its analogue form can elicit different types of pleasure and meet diverse psychological needs in different ways. It is evident in this research that the representative IoT product, smartwatches, elicited physio-pleasure, socio-pleasure and ideo-pleasure, as well as fulfilled psychological needs for relatedness, stimulation, popularity, competence, meaning and security, in ways that were different from its analogue form, traditional wristwatches. Pleasurable experiences with IoT products are found to be more complex, dynamic and flexible to shape but can benefit from established pleasure-driven design theories originally developed for analogue products. However, existing pleasure frameworks, such as Jordan's hierarchy of needs and Hassenzahl's three levels of goals for experience design, do not cover all types of interactions within an IoT system and fall short of guiding designers in integrating these theories while utilising unique features of IoT products. Thus, designing pleasurable experiences for IoT products requires additional methods.

Sub-RQ 2:

> Which methods can support the creation of novel experiences through IoT transformations based on existing pleasure-driven design theories?

Equipping designers with existing pleasure-driven theories – Jordan's four types of pleasure and Hassenzahl's six psychological needs – is indeed useful for creating novel experiences through IoT transformations. This foundational knowledge prepares them to set clear targets before initiating interventions. I contributed a new method, *the IoTT for PLEX Framework,* which guides designers in applying pleasure-driven theories and envisioning novel experiences. By summarising an experience pattern and then utilising IoT transformations as materials to recreate this pattern, the framework highlights the effectiveness of the methods of designing momentary pleasure based on experience patterns and possibility-driven design. It prioritises envisioning experiences over detailing the product features, integrates pleasure-driven theories with the unique attributes of IoT products and navigates the complexities of agency, object roles and interaction types. This integration is crucial for designers to better exploit IoT transformations in experience design. New IoT creativity-supporting tools based on pleasure-driven design can be developed following these implications: 1) paying attention to experiences derived from non-utilitarian qualities of products, 2) providing prompts for design understanding and drawing experience design knowledge from other disciplines, 3) leveraging analogue product augmentation as an experience design strategy, 4) providing guidelines for managing agency and designing detailed interactions of IoT products and 5) including evaluation criteria for designers to self-evaluate their ideas. Additionally, to effectively envision and evaluate pleasurable experiences enabled by IoT transformations, I recommend engaging interdisciplinary experts, such as HCI researchers and psychologists, through a co-speculation method.

Sub-RQ 3:

> How do pleasure-driven experience design and the transformations from analogue to IoT products influence future relationships between human beings and networked objects?

By adopting pleasure-driven design methods, designers would shift their focus from task efficiency, technical issues and profit goals to enriching emotional experiences. *The IoTT for PLEX Framework*, for example, leverages pleasure-driven design and IoT transformations to deliver pleasurable experiences by eliciting pleasure and fulfilling psychological needs in specific scenarios. IoT transformations enable the fulfilment of human psychological needs for expanded interactions. Pleasure-driven design through IoT transformations can foster connectivity between humans and objects, among humans themselves in inspirational but also provocative ways, and even with other living entities, such as plants. Nonetheless, the benefits of such transformations can be constrained by concerns over IoT products becoming overly smart and disrupting traditional social interactions, even with a pleasure-driven method. Moreover, while targeting momentary pleasure, pleasure-driven design may prompt concerns about the long-term well-being of users, highlighting a potential trade-off between immediate satisfaction and enduring impact.

The three stages of this research collectively answered the main research question:

> What new possibilities for pleasure-driven experience design are suggested by transforming an analogue product into an IoT product?

The new possibilities were embedded in the mutual relationship between pleasure-driven design and IoT transformations. IoT transformations can facilitate pleasure-driven design by enabling designers to better elicit different types of pleasure and fulfil psychological needs through product-user interaction. They allow for the recontextualisation of a pleasurable experience pattern in innovative ways, utilising both material and immaterial resources. IoT transformations can enable new methods for pleasure-driven design, such as *the IoTT for PLEX Framework* developed in this research, which facilitates a wide range of interactions, from simple one-to-one interactions between people and objects to complex interactions involving multiple objects and/or multiple people.

Pleasure-driven design can deepen designers' understanding of IoT products' agency and roles and the impacts of various interactions on experiences within an IoT system. It emphasises meaningful purposes for IoT transformations, ensuring that designs not only serve functional needs and profit growth but also contribute to users' overall emotional and societal values. This approach encourages designers to look beyond the pragmatic qualities of IoT products, urging them to explore the hedonic qualities that transform a product from merely useful to pleasurable and meaningful.

## 7.2 Original Contributions of This Research

### 7.2.1 Theory

This research advances design knowledge by critically examining the application of established pleasure-driven design approaches within IoT experience design practice. The major contribution is the development of *the IoTT for PLEX*

*Framework*. The novel framework introduces the concept of pleasure-driven design through IoT transformations, presents the implications of creating an IoT experience creativity-supporting tool and interprets the mutual relationship between IoT transformations and pleasure-driven design. Experience design theories – Jordan's four types of pleasure, Hassenzahl's six psychological needs elicited by interactive products, Hassenzahl et al.'s designing momentary pleasure based on experience patterns and Hassenzahl and Desmet's possibility-driven design – were tested in the new context of IoT transformations. This research highlights the value of integrating these experience design theories with IoT features, as these theories shift designers' focus from hardware, technology, task efficiency and profits towards enriching pleasurable experiences. It shows that Cila's taxonomy of IoT products can aid designers in understanding agency in IoT transformations and the role of IoT products in mediating pleasurable experiences. The research also draws upon psychological and philosophical discussions about pleasure and presents how these cross-disciplinary theories can deepen designers' and design researchers' understanding of the meaning of pleasure in the context of IoT experience design. Additionally, Gaver, Beaver and Benford's notion of ambiguity as a resource for design was tested, demonstrating that ambiguity can sometimes encourage creativity and novelty in designing pleasurable IoT experiences.

### 7.2.2 Methodology and Methods

The methodology developed in this research provides insights into constructing an emergent methodology within the context of experience design and IoT transformations. It shows that emergence in design research is important, particularly how my understanding of pleasure in the context of IoT transformation evolved in response to experience with people, settings, ideas and things. This adaptive approach demonstrates how to: 1) manage emergence within the research and 2) adapt new methods based on participant feedback and the evolving challenges presented by a specific technology (IoT in this thesis). This methodology exemplifies a transition from a positivist quantitative approach to a constructivist qualitative one, highlighting the value of emergence as a resource in design research aimed at exploring new possibilities and investigating subjective technology-related experiences. This research expands upon existing pleasure-driven experience design methods specifically for IoT products and develops *the IoTT for PLEX Framework.* This major contribution supports designers in envisioning pleasurable experiences and serves as a new tool for design and HCI researchers to investigate pleasure-driven design through IoT transformations. Additionally, this thesis details effective methods for conducting workshops during exceptional circumstances such as the COVID-19 pandemic, using digital tools such as Zoom and Miro. It provides reflections on conducting design research projects through hands-on, research-through-design methods, emphasising the shifting roles between designer and researcher. The design of *the CloudPlanter* offers insights into designing IoT technology probes and research products for co-speculation experiments.

### 7.2.3 Pleasurability Design

This research proposes pleasure-driven design as a new design perspective focused on facilitating momentary psychological pleasure through IoT transformations and related design practices. By integrating pleasure-driven design with IoT features, this research suggests that utilising the transformation from analogue to IoT products as materials in pleasurability design provides a novel perspective for creating more enjoyable and engaging products. The research contributes examples of pleasurability design practices, including concepts of novel pleasurable experiences (ideas developed in Workshops 1-4), research tools for supporting idea generation (*the IoTT for PLEX Framework* and three probes in Workshop 4) and a research product and technology probe developed for a co-speculation experiment (*the CloudPlanter*). The thesis, presented as an annotated portfolio, demonstrates how pleasure-driven design theories are enacted and embodied in design practices concerning IoT transformations. This portfolio benefits product designers, interaction designers and experience designers by showing how pleasure-driven theories are understood and applied in IoT contexts. It also supports design and HCI researchers by highlighting the limitations of established experience design theories and providing inspiration for developing new research tools.

## 7.3 Future Directions

This thesis opens a dialogue about pleasure design through IoT transformations. In terms of future studies, four directions are identified:

First, future research could investigate more deeply how to design for specific types of pleasurable experiences through IoT transformations. While the early studies in this research have exploratorily examined the elicitation of different forms of pleasure and the fulfilment of multiple psychological needs, the Co-speculation Experiment focused exclusively on the psychological need for relatedness, tested in real-world scenarios. Future work could involve constructing additional technology probes and research products and considering the influence of AI within IoT systems on pleasurability, based on ideas from the workshops in this research. These methods could be used to examine other psychological needs (such as stimulation, popularity, competence, meaning and security) identified in this study, which are fulfilled differently by IoT products compared to their analogue counterparts. Moreover, integrating psychological theories related to emotions into experience design to elicit various types of positive emotions represents another promising avenue. Future studies could also explore how IoT features can be utilised to introduce Desmet’s 25 types of positive emotions through research-through-design methods.

Second, future research could focus on pleasure-driven design through IoT transformations to facilitate eudaimonia. The pursuit of sustainable experiences for long-term well-being has recently become a focus in design and HCI studies and should be considered a crucial aspect of experience design with IoT. There is a noticeable shift in design focus from hedonic to eudaimonic experiences. A significant challenge for designers lies in balancing momentary pleasure with long-term meaning during the transformation from an analogue product into an IoT product. Therefore, future work in this area could explore how pleasure-driven design through the transformation from analogue to IoT products can effectively include both momentary pleasure and long-term well-being.

Third, future studies could deepen collaborations among designers, HCI researchers and psychologists engaged in pleasure-driven experiments through IoT transformations. Subsequent experiments should involve HCI researchers and psychologists from the planning stages to leverage their expertise in research design and evaluation of additional psychological theories.

Fourth, from a micro-perspective, the co-speculation experiment in this research explored the fulfilment of psychological needs for relatedness through three types of interactions: human-to-object, object-to-object and human-to-human interactions mediated by objects. Future studies could further explore pleasure-driven design through IoT transformations to address the psychological needs for relatedness in scenarios involving more complex interactions with multiple objects, people or even other living entities.

# Appendices

## Appendix A. Survey 1 Questionnaires

### Questionnaire for Smartwatch Users

Dear Potential Participant,

I am a PhD candidate in the School of Design at the Royal College of Art. As part of my studies, I am conducting a research project entitled "Investigating User Experience of Internet of Things Products through Watches." You are invited to take part in this research project, which explores the differences in user experiences between smartwatches and traditional wristwatches.

If you consent to participate, this will involve:

Answering this online survey (which takes about 15 minutes). This survey will ask you questions about your experience using smartwatches (such as Apple Watch, Fitbit, Withings Watch, etc.). Please do not answer this questionnaire if you are not a smartwatch user. If you are using a normal wristwatch, please answer the questionnaire via this link: Survey Link

Participation is entirely voluntary. You can withdraw at any time up to the point of publication, and there will be no disadvantage if you decide not to complete the study. All information collected will be confidential. All information gathered will be stored securely, and once the information has been analysed, all individual information will be destroyed. At no time will any individual be identified in any reports resulting from this study.

If you have any concerns or would like to know the outcome of this project, please enter your email address at the end of this questionnaire.

Thank you for your interest.

**Complaints Procedure:**

This project follows the guidelines laid out by the Royal College of Art Research Ethics Policy.

If you have any questions, please speak with the researcher. If you have any concerns or a complaint about the manner in which this research is conducted, please contact the RCA Research Ethics Committee by emailing ethics@rca.ac.uk or by sending a letter addressed to:

The Research Ethics Committee
Royal College of Art
Kensington Gore
London
SW7 2EU

### Part 1. Basic Information

**Q1. What is your gender?**

☐ Female ☐ Male ☐ Prefer not to say

**Q2. What is your age group?**

☐under 18 ☐18–24 ☐25–39 ☐40–60 ☐60+

**Q3. What's your nationality?**

**Q4. Which country are you currently living in?**

**Q5. What is the brand and the model of your smartwatch?**

**Q6. How long have you been using your smartwatch?**

☐less than half a year ☐1/2 year-1 year

☐1year-3years ☐over 3 years

## Part 2. Pleasurable Experiences

**Q7. How would you rate the experiences of touch during the interaction with your smartwatch?**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Q8. Please rate the enjoyment of using your smartwatch in a social context, i.e. the enjoyment derived from relationships with others such as friends, loved ones, colleagues or likeminded people.**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Q9. Please rate how your smartwatch affects your overall emotional and state of mind.**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Q10. Please rate how your smartwatch affects your feelings about your personal goals and personal values.**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Q11. Please rate how your smartwatch affects your thinking and emotions, in relation to each of the aspects below.**

**Having regular intimate contact with people who care about you**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Getting plenty of motivation and stimulation**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

## Part 3. Open-ended Questions

**Q12. Are there any special reasons why you wear your smartwatch?**

**Q13. Do you have other opinions about the experiences of using smartwatches?**

## Questionnaire for Wristwatch Users

Dear Potential Participant,

I am a PhD candidate in the School of Design at the Royal College of Art. As part of my studies, I am conducting a research project entitled "Investigating User Experience of Internet of Things Products through Watches." You are invited to take part in this research project, which explores the differences in user experiences between smartwatches and traditional wristwatches.

If you consent to participate, this will involve:

Answering this online survey (which takes about 15 minutes). This survey will ask you questions about your experience using wristwatches (which could be either mechanical or electronic quartz). Please do not answer this questionnaire if you are not a wristwatch user. If you are using a smartwatch, please answer the questionnaire via this link: Survey Link

Participation is entirely voluntary. You can withdraw at any time up to the point of publication, and there will be no disadvantage if you decide not to complete the study. All information collected will be confidential. All information gathered will be stored securely, and once the information has been analysed, all individual information will be destroyed. At no time will any individual be identified in any reports resulting from this study.

Thank you for your interest.

**Complaints Procedure:**

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If you have any questions, please speak with the researcher. If you have any concerns or a complaint about the manner in which this research is conducted, please contact the RCA Research Ethics Committee by emailing ethics@rca.ac.uk or by sending a letter addressed to:

The Research Ethics Committee
Royal College of Art
Kensington Gore
London
SW7 2EU

## Part 1. Basic Information

**Q1. What is your gender?**

☐ Female ☐ Male ☐ Prefer not to say

**Q2. What is your age group?**

☐under 18 ☐18–24 ☐25–39 ☐40–60 ☐60+

**Q3. What's your nationality?**

**Q4. Which country are you currently living in?**

**Q5. What is the brand and the model of your wristwatch?**

**Q6. How long have you been using your wristwatch?**

☐less than half a year ☐1/2 year-1 year
☐1year-3years ☐over 3 years

## Part 2. Pleasurable Experiences

**Q7. How would you rate the experiences of touch during the interaction with your wristwatch?**

☐Extremely unpleasurable
☐Very unpleasurable
☐Slightly unpleasurable
☐Neutral
☐Slightly pleasurable
☐Very pleasurable
☐Extremely pleasurable

**Q8. Please rate the enjoyment of using your wristwatch in a social context, i.e. the enjoyment derived from relationships with others such as friends, loved ones, colleagues or likeminded people.**

☐Extremely unpleasurable
☐Very unpleasurable
☐Slightly unpleasurable
☐Neutral
☐Slightly pleasurable
☐Very pleasurable
☐Extremely pleasurable

**Q9. Please rate how your wristwatch affects your overall emotional and state of mind.**

☐Extremely unpleasurable
☐Very unpleasurable
☐Slightly unpleasurable
☐Neutral
☐Slightly pleasurable
☐Very pleasurable
☐Extremely pleasurable

**Q10. Please rate how your wristwatch affects your feelings about your personal goals and personal values.**

☐Extremely unpleasurable
☐Very unpleasurable
☐Slightly unpleasurable
☐Neutral
☐Slightly pleasurable
☐Very pleasurable
☐Extremely pleasurable

**Q11. Please rate how your wristwatch affects your thinking and emotions, in relation to each of the aspects below.**

**Having regular intimate contact with people who care about you**

☐Extremely unpleasurable
☐Very unpleasurable
☐Slightly unpleasurable
☐Neutral
☐Slightly pleasurable
☐Very pleasurable

☐Extremely pleasurable

**Getting plenty of motivation and stimulation**

☐Extremely unpleasurable
☐Very unpleasurable
☐Slightly unpleasurable
☐Neutral
☐Slightly pleasurable
☐Very pleasurable
☐Extremely pleasurable

**Being liked, respected, and have influence over others**

☐Extremely unpleasurable
☐Very unpleasurable
☐Slightly unpleasurable
☐Neutral
☐Slightly pleasurable
☐Very pleasurable
☐Extremely pleasurable

**Being capable and effective in your actions**

☐Extremely unpleasurable
☐Very unpleasurable
☐Slightly unpleasurable
☐Neutral
☐Slightly pleasurable
☐Very pleasurable
☐Extremely pleasurable

**Developing your best potential and making life meaningful**

☐Extremely unpleasurable
☐Very unpleasurable
☐Slightly unpleasurable
☐Neutral
☐Slightly pleasurable
☐Very pleasurable

☐Extremely pleasurable

**Feeling safe and in control of your life**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

## Part 3. Open-ended Questions

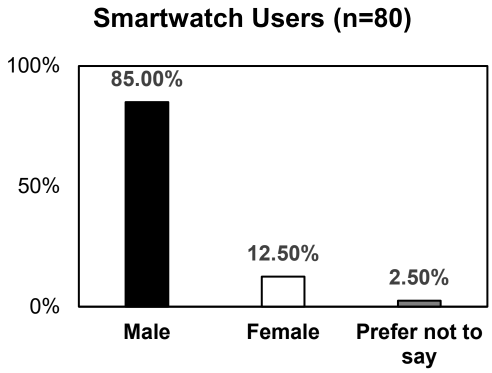
**Q12. Are there any special reasons why you wear your wristwatch?**

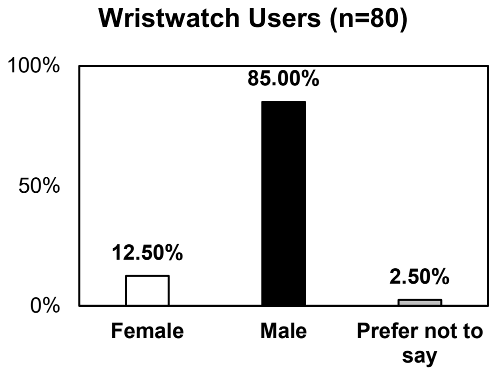
**Q13. Do you have other opinions about the experiences of using wristwatches?**

# Appendix B. Survey 1 Results Summary

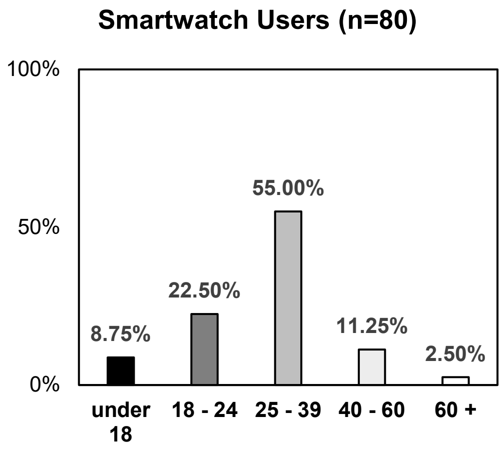
## Part 1. Basic Information

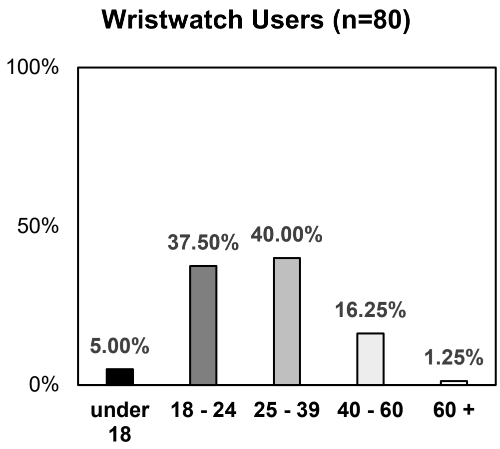
### Q1. What is your gender?



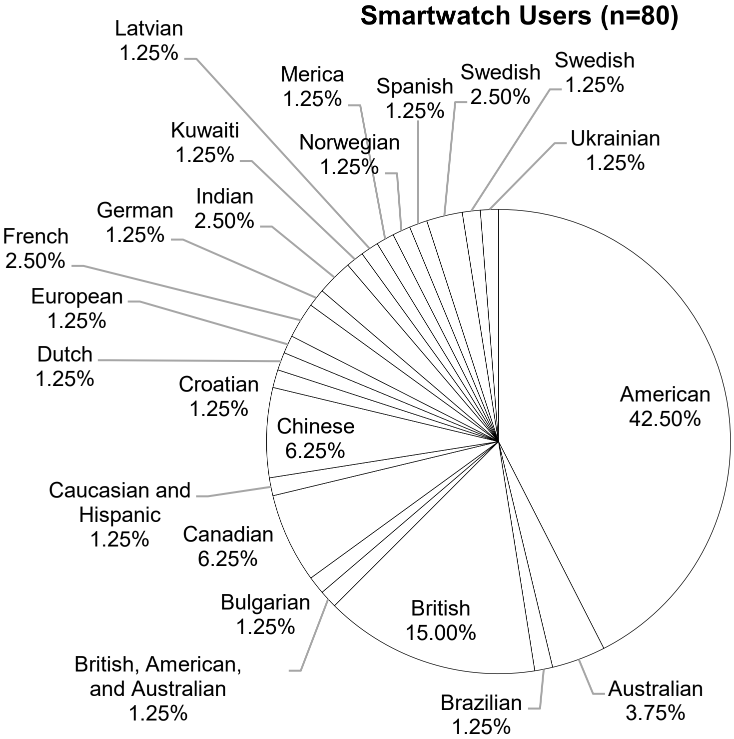



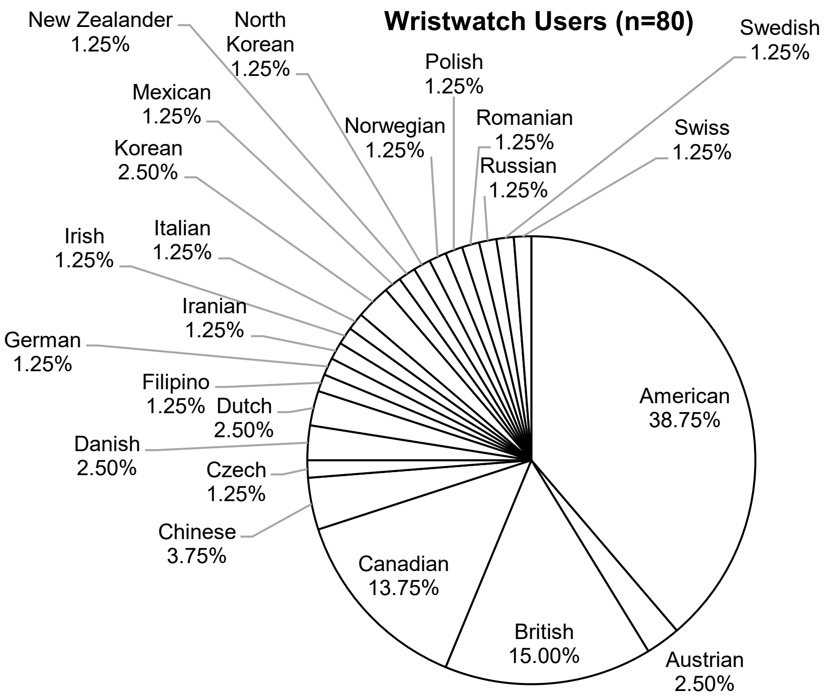

### Q2. What is your age group?



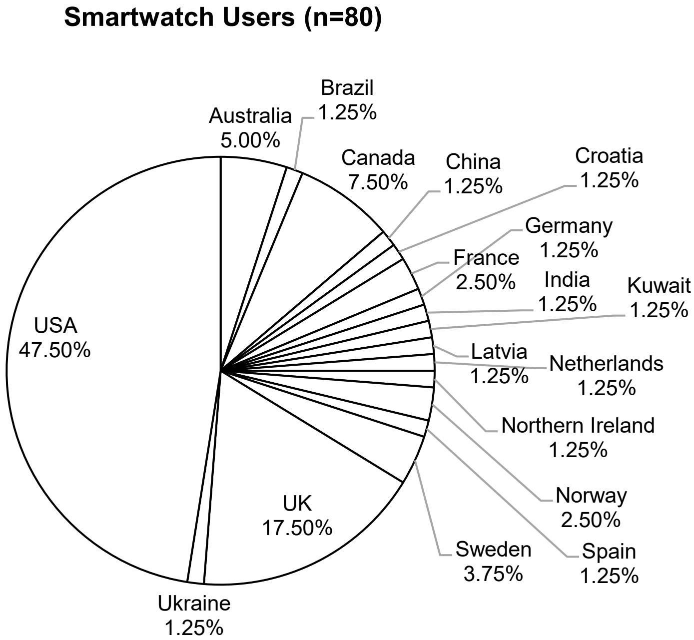



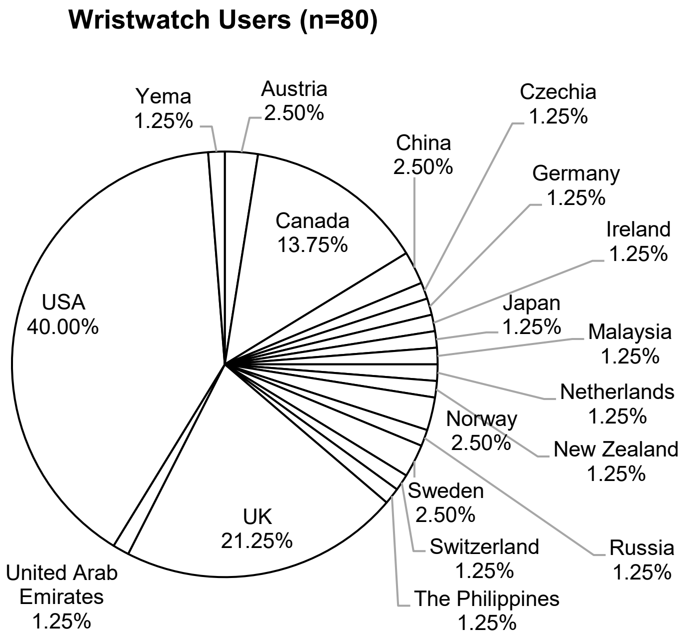
**Q3. What's your nationality?**



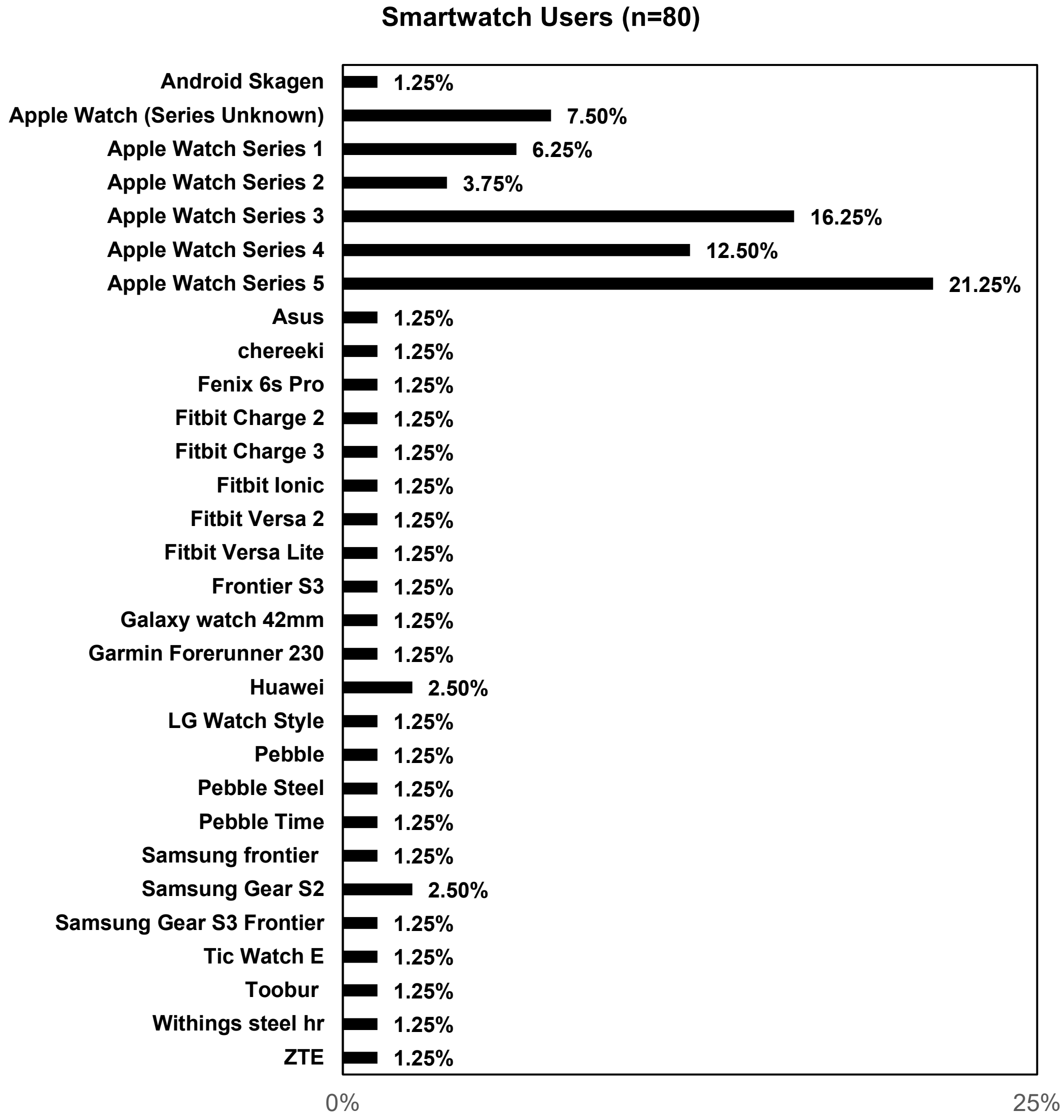



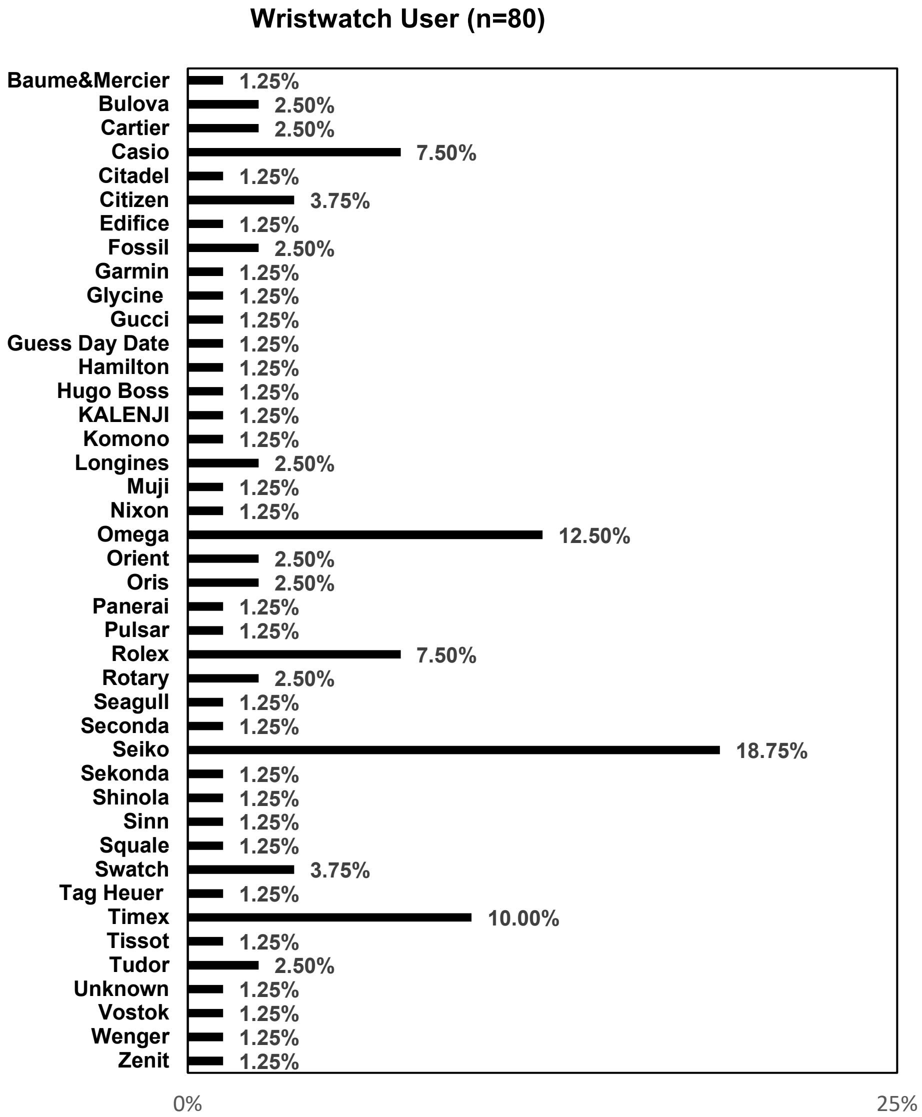
## Q4. Which country are you currently living in?



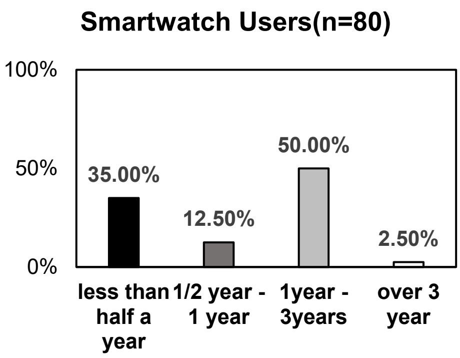



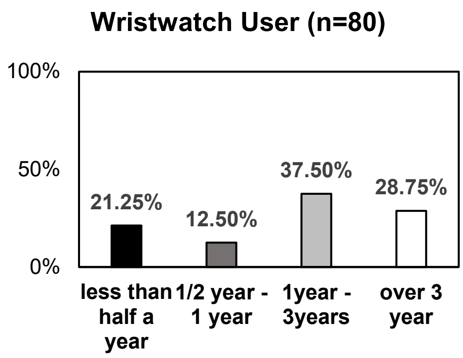
**Q5. What is the brand and the model of your smartwatch/wristwatch?**





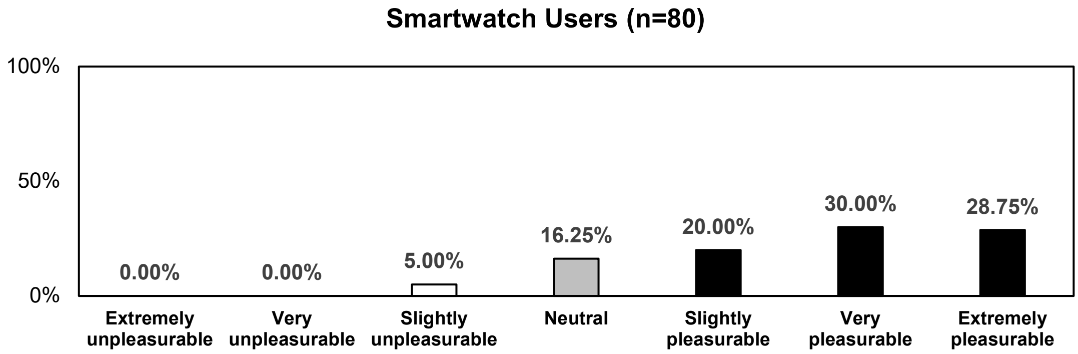

**Q6. How long have you been using your smartwatch/wristwatch?**

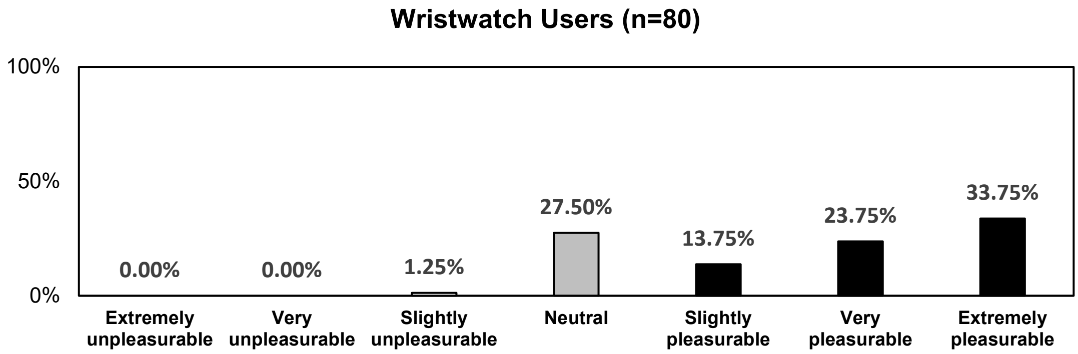


## Part 2. Pleasurable Experiences

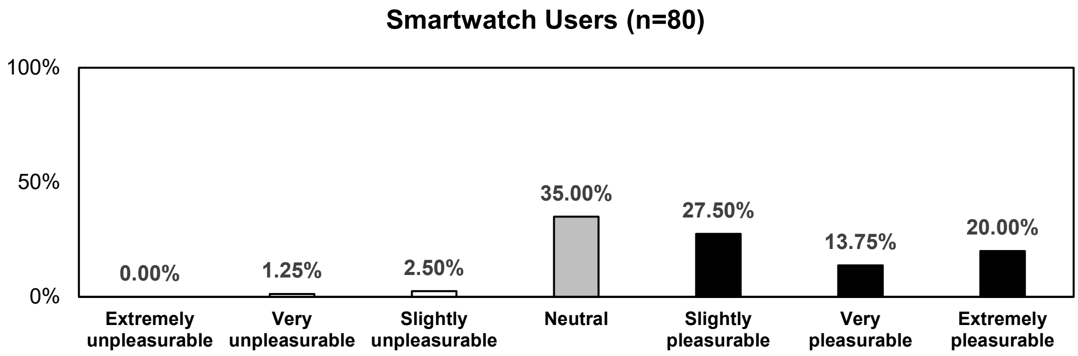
### Q7. [Physio-pleasure] How would you rate the experiences of touch during the interaction with your smartwatch/wristwatch?

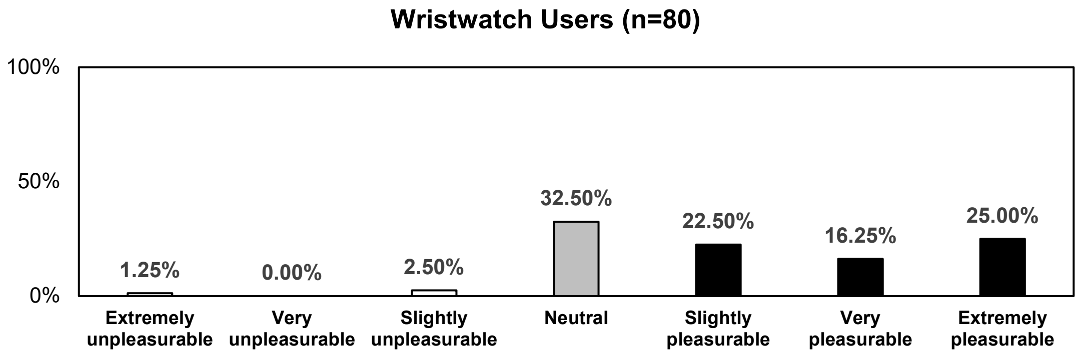



| Physio-pleasure | Smartwatch Users | Wristwatch Users |
|---|---|---|
| **Mean** | 1.612 | 1.612 |
| **SD** | 1.248 | 1.324 |
| **Variance** | 1.456 | 1.557 |
| **t-test (p)** | 1.000 | |

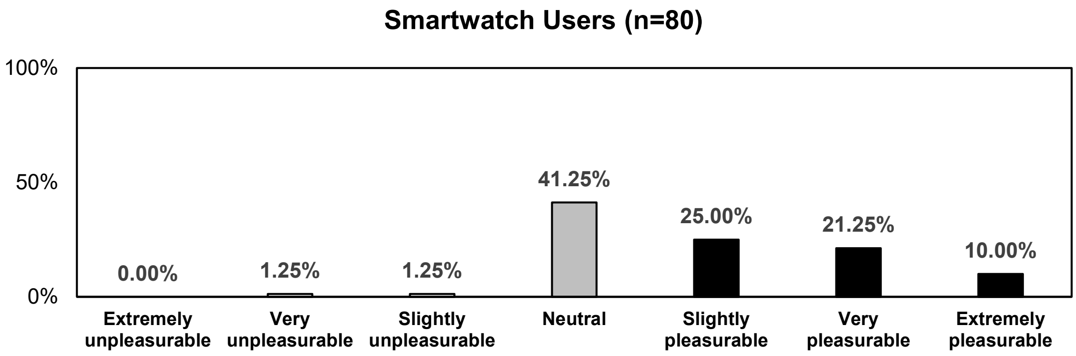
**Q8. [socio-pleasure] Please rate the enjoyment of using your smartwatch in a social context, i.e. the enjoyment derived from relationships with others such as friends, loved ones, colleagues or likeminded people.**

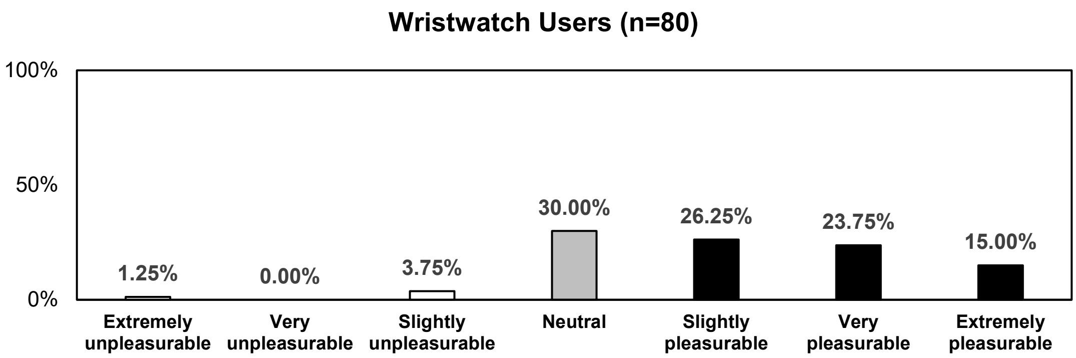



| Socio-pleasure | Smartwatch Users | Wristwatch Users |
|---|---|---|
| **Mean** | 1.100 | 1.237 |
| **SD** | 1.228 | 1.219 |
| **Variance** | 1.508 | 1.753 |
| **t-test (p)** | 0.497 | |

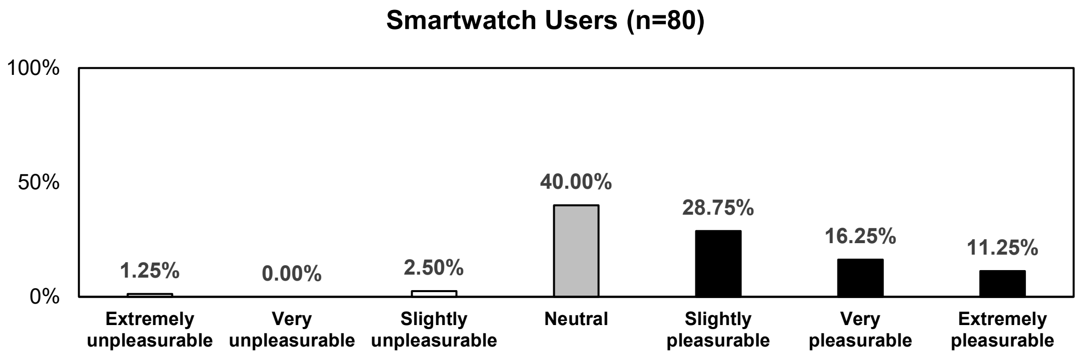
**Q9. [psycho-pleasure] Please rate how your smartwatch affects your overall emotional and state of mind.**

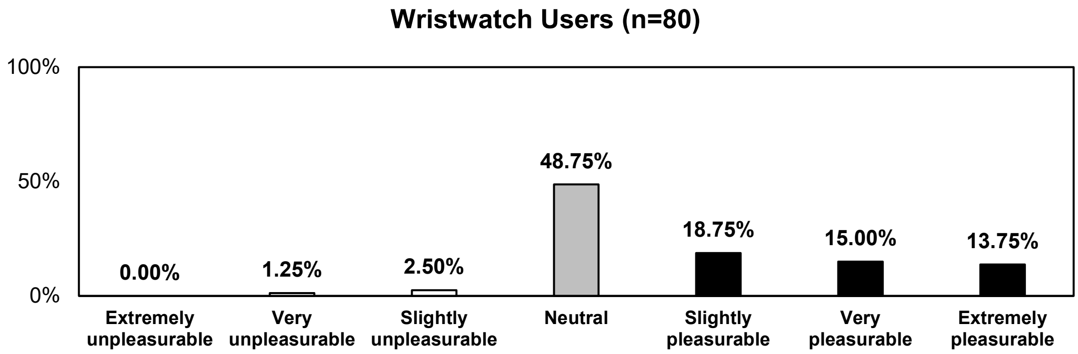



| Psycho-pleasure | Smartwatch Users | Wristwatch Users |
|---|---|---|
| **Mean** | 0.938 | 1.113 |
| **SD** | 1.095 | 1.222 |
| **Variance** | 1.199 | 1.494 |
| **t-test (p)** | 0.342 | |

**Q10. [ideo-pleasure] Please rate how your smartwatch affects your feelings about your personal goals and personal values.**

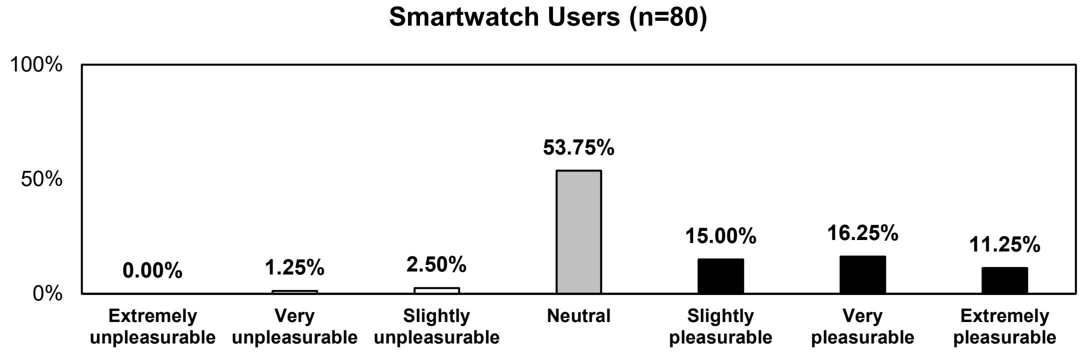


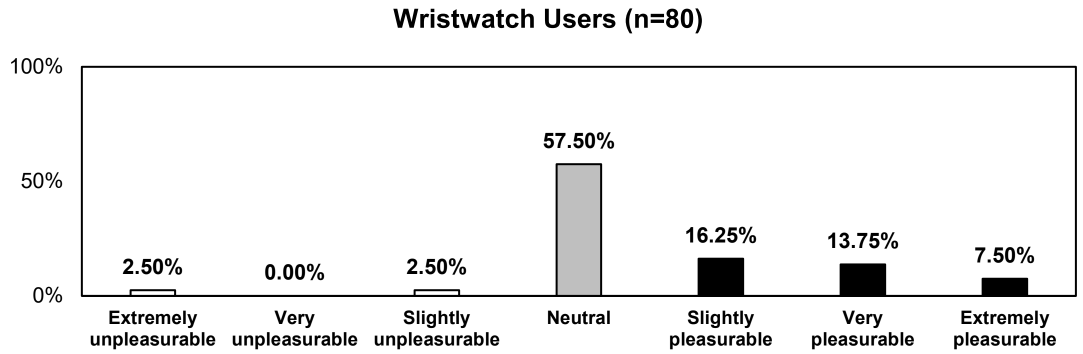




| Ideo-pleasure | Smartwatch Users | Wristwatch Users |
|---|---|---|
| Mean | 0.888 | 0.850 |
| SD | 1.453 | 1.181 |
| Variance | 1.316 | 1.395 |
| t-test (p) | 0.839 | |

**Q11. Please rate how your smartwatch affects your thinking and emotions, in relation to each of the aspects below.**

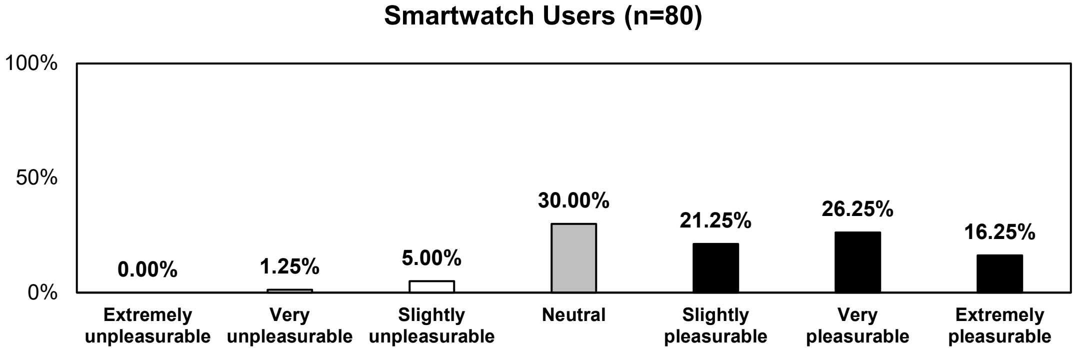
**[Relatedness] Having regular intimate contact with people who care about you**

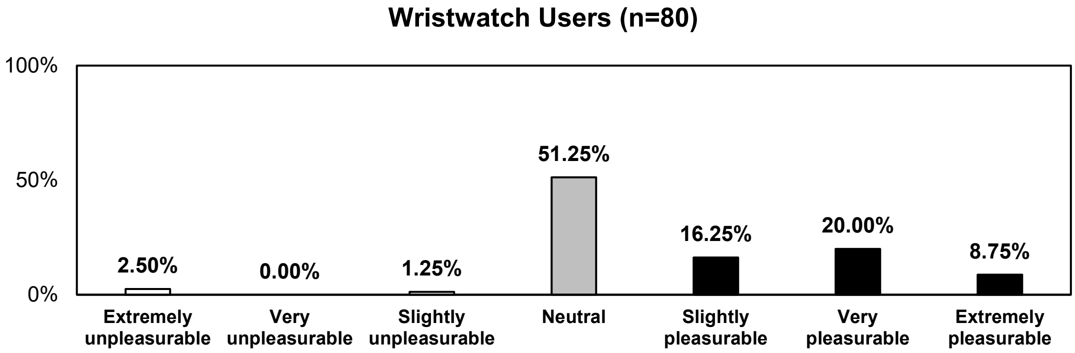



| Relatedness | Smartwatch Users | Wristwatch Users |
|---|---|---|
| Mean | 0.763 | 0.563 |
| SD | 1.150 | 1.157 |
| Variance | 1.323 | 1.338 |
| t-test (p) | 0.274 | |

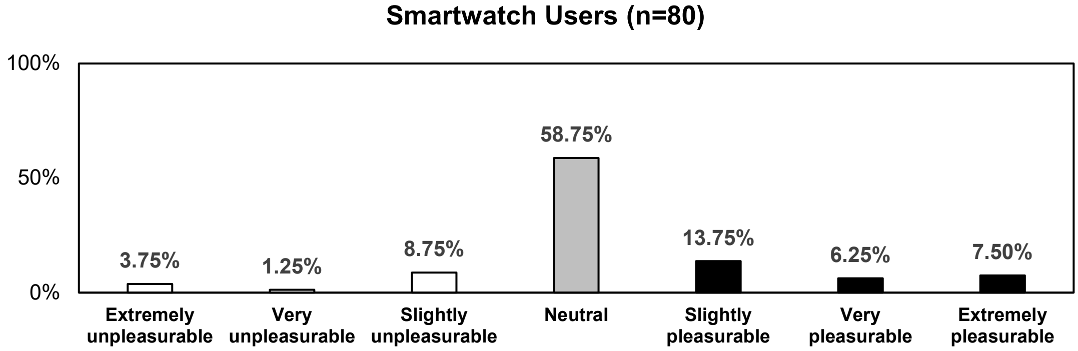
## [Stimulation] Getting plenty of motivation and stimulation

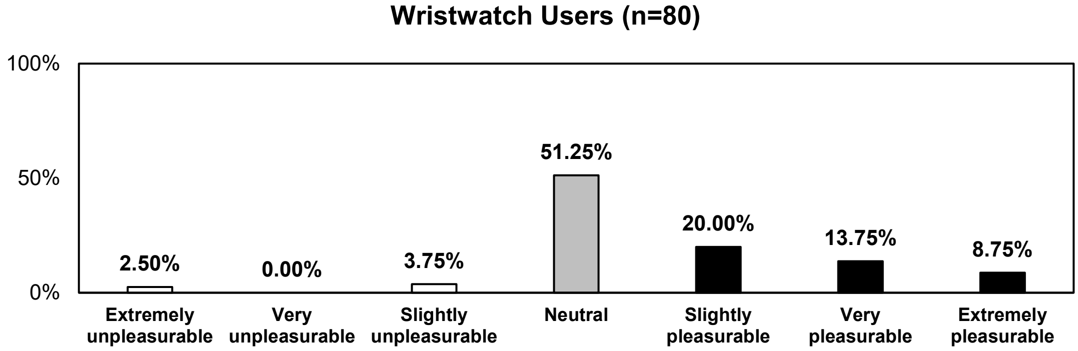



| **Stimulation** | **Smartwatch Users** | **Wristwatch Users** |
|---|---|---|
| **Mean** | 1.150 | 0.738 |
| **SD** | 1.233 | 1.209 |
| **Variance** | 1.522 | 1.462 |
| **t-test (p)** | 0.034 | |

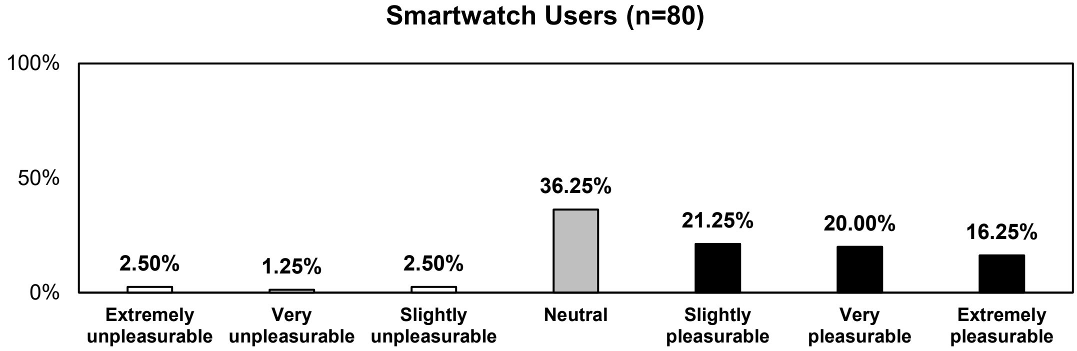
**[Popularity] Being liked, respected, and have influence over others**

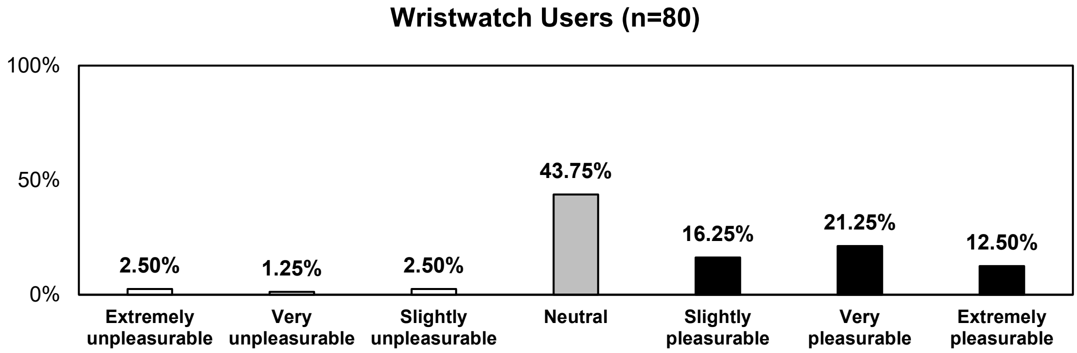



| **Popularity** | **Smartwatch Users** | **Wristwatch Users** |
|---|---|---|
| **Mean** | 0.263 | 0.625 |
| **SD** | 1.220 | 1.195 |
| **Variance** | 1.487 | 1.427 |
| **t-test (p)** | 0.059 | |

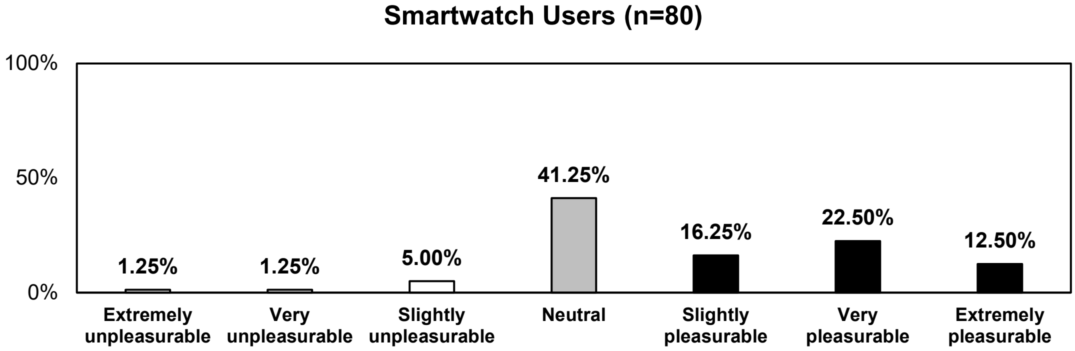
### [Competence] Being capable and effective in your actions

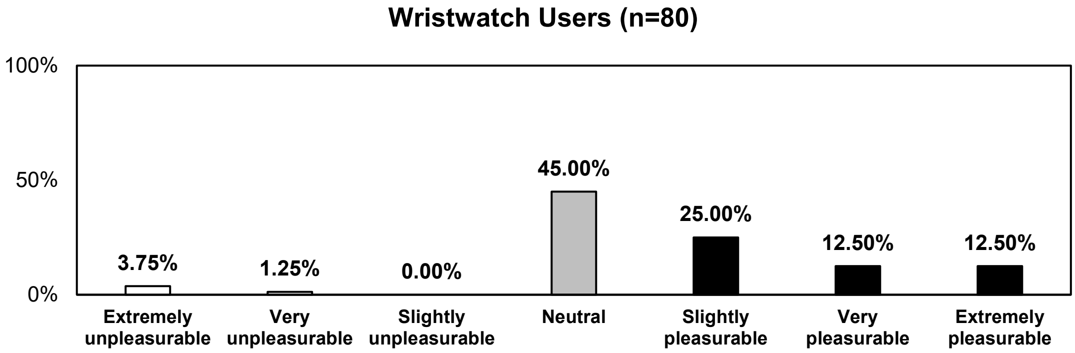



| Competence | Smartwatch Users | Wristwatch Users |
|---|---|---|
| **Mean** | 0.975 | 0.838 |
| **SD** | 1.359 | 1.326 |
| **Variance** | 1.847 | 1.758 |
| **t-test (p)** | 0.518 | |

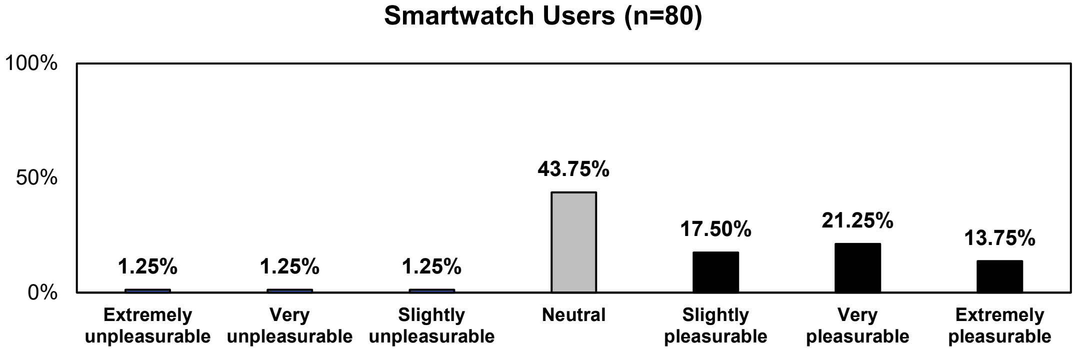
## [Meaning] Developing your best potential and making life meaningful

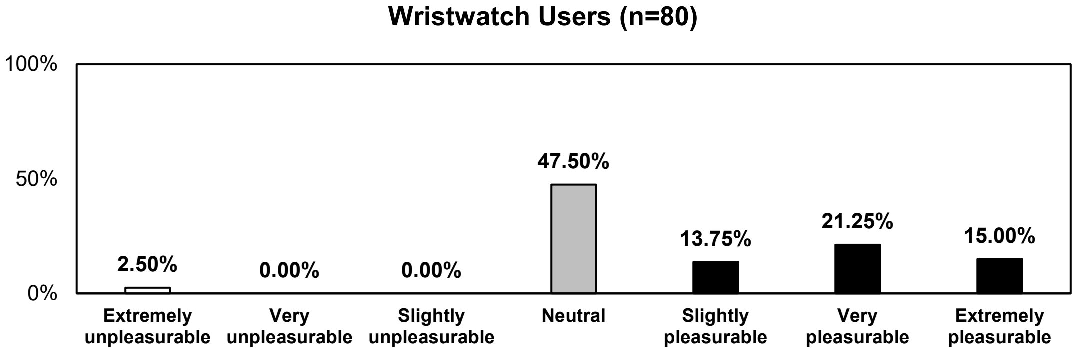



| Meaning | Smartwatch Users | Wristwatch Users |
|---|---|---|
| **Mean** | 0.875 | 0.738 |
| **SD** | 1.286 | 1.319 |
| **Variance** | 1.655 | 1.740 |
| **t-test (p)** | 0.505 | |

**[Security] Feeling safe and in control of your life**




| Security | Smartwatch Users | Wristwatch Users |
|---|---|---|
| **Mean** | 0.938 | 0.938 |
| **SD** | 1.256 | 1.306 |
| **Variance** | 1.578 | 1.705 |
| **t-test (p)** | 1.000 | |

## Part 3. Open-ended Questions

### Q12. Are there any special reasons why you wear your smartwatch/wristwatch?

**Smartwatch Users**

| Participant id | Answer |
|---|---|
| **SU1** | Use it as a watch and fitness tracking |
| **SU3** | Notifications is definitely the biggest reason |
| **SU4** | keep track of bedtime, and wake up times |
| **SU7** | Monitoring chronic pain conditions, monitoring illnesses, helping |

| | |
|---|---|
| | to stay active despite pain conditions, so I don’t get lost on hikes all the time |
| **SU9** | I like collecting watch bands |
| **SU12** | I feel cool wearing it |
| **SU19** | Health issues and health tracking |
| **SU22** | It was a present |
| **SU23** | To not miss important notifications sent to my phone. For convenience of not always having to pull my phone out of my pocket to read a notification |
| **SU24** | Not always near phone |
| **SU25** | Just always have and are used to it. Had one since 2015 |
| **SU27** | Health tracker, media controls |
| **SU28** | Mainly for sleep tracking tbh |
| **SU29** | To keep an eye on important notifications while at work. To keep my off my phone at home. Apple Pay. |
| **SU30** | Mostly the fitness stuff. The activity rings and challenges really motivate me to move more and exercise |
| **SU31** | At first it was purely fitness related, but has since become fully integrated into my everyday routine. |
| **SU32** | Fitness/sleep tracking, giving me notifications for calls/texts (phone on silent, I would otherwise miss a lot of notifications). |
| **SU40** | Doesn’t require me to check phone for every notifications |
| **SU42** | So I don’t have to check my phone when I am busy in meetings or school |
| **SU44** | Integration with mobile + desktop |
| **SU45** | I like having notifications on my wrist so I don’t have to constantly look at my phone |
| **SU49** | I like having a "dashboard" available at all times |
| **SU51** | The Ionic has a week of battery life. That’s good enough for it to replace my normal watch. I also use it for sleep tracking. |
| **SU52** | Like tech, good watch, keep phone on silent, watch vibrates for calls/notifications |
| **SU54** | Can’t always be on my phone |
| **SU55** | Sleep tracker |
| **SU56** | I like having a watch and a fitness tracker, and this one has a ton of bonus features |
| **SU58** | can’t hear my phone ring |

| | |
|---|---|
| **SU59** | Helps me not check my phone |
| **SU60** | like to track steps and heart rate |
| **SU61** | Noise tracking |
| **SU70** | Convenience |
| **SU72** | Because I am losing weight and like to keep track of how many calories I have burned during the day. |
| **SU73** | It is illegal to use a mobile phone while driving so the watch gives me all the functions that I need while driving. |
| **SU74** | Help me to check the notifications is important or not without taking out the phone from pocket |
| **SU75** | Quicker and easier way to read notifications and to set up reminders |
| **SU76** | Flex |
| **SU79** | Sometimes when dressing up a bit or going out |

**Wristwatch Users**

| **Participant id** | **Answer** |
|---|---|
| **WU1** | Special meaning to me |
| **WU2** | Function and fashion |
| **WU3** | It's a piece of mechanical reliability in an electronic world. And also I'm very keen on being on time so i check my watch every other minute. Plus it looks gorgeous |
| **WU4** | Looks nice |
| **WU5** | I like the look, and I enjoy having a watch on. |
| **WU6** | quicker than getting phone out of pocket, waking it up, entering passcode etc to look at time |
| **WU7** | Special? I originally got it because I was working as a waiter running events and needed to keep time, without looking like I was on my phone in front of guests. Now it is mostly for gym, cooking and travel. |
| **WU9** | Looks/outfit |
| **WU10** | I like the design |
| **WU11** | Outfit |
| **WU12** | Fashion and function |
| **WU13** | It's how I grew up. |

| | |
|---|---|
| **WU14** | Looks very beautiful, trusted brand, the crystal is not as scratched as my Seiko 5 that I wear outside and at home. |
| **WU15** | I enjoy collecting wrist watches. Started recently |
| **WU16** | tell time |
| **WU18** | Aesthetics |
| **WU20** | Simplicity with functional style |
| **WU21** | Only for meetings where it would be unpolite to lock at my smartphone for time |
| **WU22** | It becomes a habit. |
| **WU23** | Timing. Pretend to be busy.....that's true. |
| **WU25** | I have many watches and I try to match them with my outfit. |
| **WU26** | Style |
| **WU27** | Not really |
| **WU28** | To tell the time. I work in environments that electronics are not allowed. (Military) |
| **WU29** | It was a gift from a family member. |
| **WU30** | I don't want to have to pull my phone out all the time to check the time. Especially in cities that are a bit less safe than London. |
| **WU31** | Feel dressed :-) |
| **WU32** | Can wear underwater |
| **WU33** | It's part of who I am. |
| **WU34** | I like it |
| **WU37** | I don't like to pull out my phone in class/social occasions but I am quite punctual and like to know what time it is. My watch allows me to still know what time it is without pulling it a phone in class or conversation. |
| **WU38** | I got it as a present. |
| **WU39** | I like how it looks |
| **WU42** | I like to always be aware of the current time, and checking my wristwatch is the easiest way to remain up-to-date on the current time. |
| **WU48** | As jewelery |
| **WU49** | I really love the design, complexity of the mechanics, and just generally wearing it. |
| **WU50** | The notion of not having to look at your phone or asking someone to know what time it is, or in some cases a family |

| | |
|---|---|
| | heirloom, plus a timepiece is a work of art. |
| **WU53** | I like wearing it and it's useful to be able to check the time without having to get my phone out. |
| **WU54** | It's one of very few acceptable accessories for men |
| **WU55** | I like mechanical things, and as a mechanical engineer I appreciate the complexity of a mechanical watch |
| **WU56** | Nostalgia, love of horological history, aesthetics |
| **WU58** | It makes me happy |
| **WU59** | Style, sentimental reasons, function |
| **WU60** | Helps me interface with my phone easier when out and about as it's a smartwatch |
| **WU62** | Acceptable as jewelery in a professional environment |
| **WU63** | I don't have a phone with me at all times, the watch is always there |
| **WU64** | Birthday gift for my 18th |
| **WU65** | it tells the time |
| **WU66** | Love of engineering, aesthetics |
| **WU67** | I wear a suit and I feel that a watch contributes to that style. |
| **WU68** | Ease of use, style, personality |
| **WU70** | It's the only part of men's fashion I really pay attention to. |
| **WU71** | Just admire them |
| **WU72** | Casual looking and comfy |
| **WU73** | The one I am wearing today is very sentimental |
| **WU74** | I enjoy the weight/heft of the timepiece and love the history/soul |
| **WU75** | Sophistication, class |

**Q13. Do you have other opinions about the experiences of using smartwatches /wristwatches?**

**Smartwatch Users**

| **Participant id** | **Answer** |
|---|---|
| **SU1** | I wish more would be released that look like a traditional wristwatch. I don't like the modern look of most smart watches. |
| **SU3** | I wish Pebble was still around today |
| **SU7** | Wish social aspect was a little more well rounded the way it was |

| | |
|---|---|
| | on FitBit. The sleep tracking needs a complete overhaul. |
| **SU9** | It is the most personal (and I would even say intimate) gadget. You literally wear it all day long (and you can even wear it at night to use sleep tracking). I cannot imagine being without that piece of tech on my wrist |
| **SU18** | This study is bizarre. The watch is a tool, primarily used to give me sports tracking each day and act as a less obnoxious extension of my phone. I don't have a special emotional connection to using it. |
| **SU25** | It's good if only to flex on people |
| **SU26** | I seldom use it anymore. Back to just a regular watch. |
| **SU27** | Has motivated me to get healthier due to the health tracking, so worth it just because of that |
| **SU28** | It's really not anything special tbh |
| **SU31** | My watch allows me to be free of the burden of having my phone on my person 24/7. I've currently have to carry 2 cell phones (business and personal) and after 10 years of doing so getting rid of one of them was truly liberating. |
| **SU33** | Pebble needs to come back. Sunlight readable long battery life simple functioning watches beat everything else. |
| **SU36** | Siri is unusable after watch os6 |
| **SU38** | I think a lot of these questions are mad. I don't think my wearing or not wearing a smart watch has any bearing whatsoever on things like "making my life meaningful" or connecting to "other people's values". |
| **SU45** | No smart watch on the market has all of the features I want. Buying and using a smart watch means choosing the best option available, but not being totally happy. |
| **SU51** | A smart watch is a tool that serves a purpose (tell time, see what email/calls are coming in, track fitness, etc). A watch does not affect my emotional state. Anyone who'd give a strong answer to q16-18 needs to seriously re-evaluate their life. |
| **SU54** | Although I like some aspects of smart watches I do not believe they make a suitable replacement for classic mechanical time pieces |
| **SU61** | Have not used some of the features - such as social media - on my Apple Watch yet |

| | |
|---|---|
| **SU68** | It is very convenient to use with earphones. |
| **SU70** | very good |
| **SU73** | I would have used over 10 different smart watches as I couldn't afford an Apple. I finally managed to buy 3 faulty watches and build one from them and it is absolutely perfect. It works seamlessly with my phone and lets me do all the main features I need. I have very few criticisms of the watch but my main one would be the lack of custom faces we are able to select. I can customise my phones look very easily, but I can't do the same with my watch. |
| **SU74** | Only Apple is heading to the right direction. |
| **SU78** | I rarely use it anymore because I no longer have much use for its notification features. |

**Wristwatch Users**

| **Participant id** | **Answer** |
|---|---|
| **WU5** | It's just fun |
| **WU8** | It's just a watch. There is nothing special about it. |
| **WU9** | No, it's just a simple watch i use to check time |
| **WU15** | Sometimes I wish I feel a watch is out of reach that someone else has, which isn't always a good feeling |
| **WU18** | I just like to wear it i have no other feelings about it. |
| **WU20** | Buy what you like vs an investment. However if you find what you like for a great price, it's a good investment. |
| **WU21** | I hate wearing a watch. It's like a slave's collar. |
| **WU23** | It is still so personal and private experience to share like a handkerchief. |
| **WU25** | It signals that your time is important. |
| **WU29** | The wristwatch is a great device for fashion and time-keeping. Given the option, I will definitely acquire more watches in the future. |
| **WU30** | It makes me feel in control and on top of what I am doing. |
| **WU34** | I like it |
| **WU40** | I have Tourette's and one of my tics involves wiping off the face of my watch, so it's pretty important to me in that sense |
| **WU41** | A watch is just a tool to tell the time. |

| | |
|---|---|
| **WU50** | Using a wristwatch makes me feel secure. |
| **WU51** | It helps me get the pussy! |
| **WU52** | My watch is a very nice watch, the best one I've ever had, but it is only a watch. |
| **WU53** | I just like wearing it. |
| **WU58** | Wearing a watch isn't supposed to be logical, you do it because you want to |
| **WU60** | Don't necessarily tie the use of my watch to emotional loss of gain |
| **WU63** | It tells the time, and looks nice. That is all. |
| **WU70** | I have multiple that I use based on the mood I am when I wake up in the morning. It might be interesting to factor that in. |
| **WU73** | It's a work of art on my wrist. |
| **WU75** | I have too many watches |

# Appendix C. Survey 2 Questionnaire

### Smartwatch and Wristwatch Experience Questionnaire

Dear Potential Participant,

I am a PhD candidate in the School of Design at the Royal College of Art. As part of my studies, I am conducting a research project entitled "Investigating User Experience of Internet of Things Products through Watches." You are invited to take part in this research project, which explores the differences in user experiences between smartwatches and traditional wristwatches.

If you consent to participate, this will involve:

Answering this online survey (which takes about 20 minutes). This survey will ask you questions about your experiences using smartwatches (such as Apple Watch, Fitbit, Withings Watch, etc.) and traditional wristwatches (which could be either mechanical or electronic quartz). Please do not answer this questionnaire if you do not have experience using both kinds of watches.

Participation is entirely voluntary. You can withdraw at any time up to the point of publication, and there will be no disadvantage if you decide not to complete the study. All information collected will be confidential. All information gathered will be stored securely, and once the information has been analysed, all individual information will be destroyed. At no time will any individual be identified in any reports resulting from this study.

Thank you for your interest.

**Complaints Procedure:**

This project follows the guidelines laid out by the Royal College of Art Research Ethics Policy.

If you have any questions, please speak with the researcher. If you have any concerns or a complaint about the manner in which this research is conducted, please contact the RCA Research Ethics Committee by emailing ethics@rca.ac.uk or by sending a letter addressed to:

The Research Ethics Committee

Royal College of Art

Kensington Gore

London

SW7 2EU

## Part 1. Basic Information

**Q1. What is your gender?**

☐Female ☐Male ☐Prefer not to say

**Q2. What is your age group?**

☐under 18 ☐18–24 ☐25–39 ☐40–60 ☐60+

**Q3. What's your nationality?**

**Q4. Which country are you currently living in?**

**Q5. What is the brand(s) and the model(s) of your SMARTWATCH(ES)? (You may find it on the back of your watch)**

**Q6. What is the brand(s) and the model(s) of your WRISTWATCH(ES)? (You may find it on the back of your watch)**

**Q7. How long did you use your SMARTWATCH(ES)you're your WRISTWATCH(ES)?**

☐Less than half a year ☐1/2year-1year ☐1year-3years ☐over 3 years

## Part 2. Pleasurable experiences of Smartwatches and Wristwatches

**Q8. How would you rate the experiences of touch during the interaction with your SMARTWATCH(ES) and WRISTWATCH(ES)?**

**Smartwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Wristwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Q9. Please rate the enjoyment of using your SMARTWATCH(ES) and WRISTWATCH(ES) in a social context, i.e. the enjoyment derived from relationships with others such as friends, loved ones, colleagues or likeminded people.**

**Smartwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Wristwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Q10. Please rate how your SMARTWATCH(ES) and WRISTWATCH(ES) affect your overall emotional and state of mind.**

**Smartwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Wristwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Q11. Please rate how your SMARTWATCH(ES) and WRISTWATCH(ES) affect your feelings about your personal goals and personal values.**

**Smartwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Wristwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Q12. Please rate how your SMARTWATCH(ES) and WRISTWATCH(ES) affect your thinking and emotions, in relation to each of the aspects below.**

**Having regular intimate contact with people who care about you**

**Smartwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Wristwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Getting plenty of motivation and stimulation**

**Smartwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Wristwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Being liked, respected, and have influence over others**

**Smartwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Wristwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Being capable and effective in your actions**

**Smartwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Wristwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Developing your best potential and making life meaningful**

**Smartwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Wristwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Feeling safe and in control of your life**

**Smartwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Wristwatch(es)**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Q13. Do you have other opinions about the experiences of using SMARTWATCH(ES) and WRISTWATCH(ES) in terms of their enjoyment?**

## Part 3. Overall Experience

**Q14. What kind of watch are you currently using?**

☐SMARTWATCH(ES) ☐WRISTWATCH(ES) ☐Both

**Q15. Please give reasons why you abandoned SMARTWATCH(ES)/WRISTWATCH(ES) or why you are using both.**

**Q16. Which type of watches provided you better overall experience do you think? ***

☐SMARTWATCH(ES) ☐WRISTWATCH(ES) ☐ Same

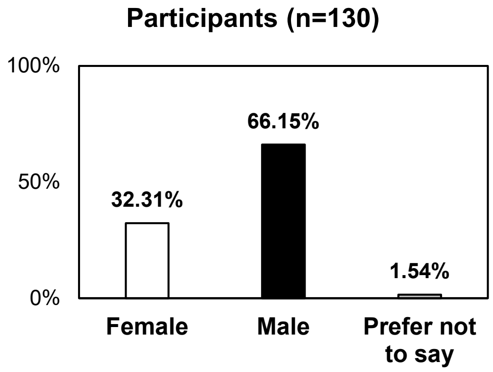
**Q17. Please explain the reasons for your choice in the last question. (Why does that**

**type of watch provide you better user experience? or why do you think their experience is the same?)**

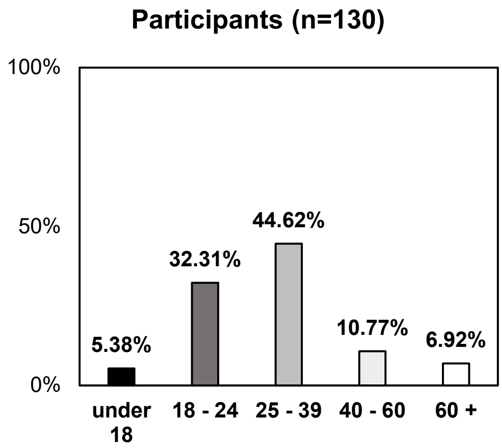
# Appendix D. Survey 2 Results Summary

## Part 1. Basic Information

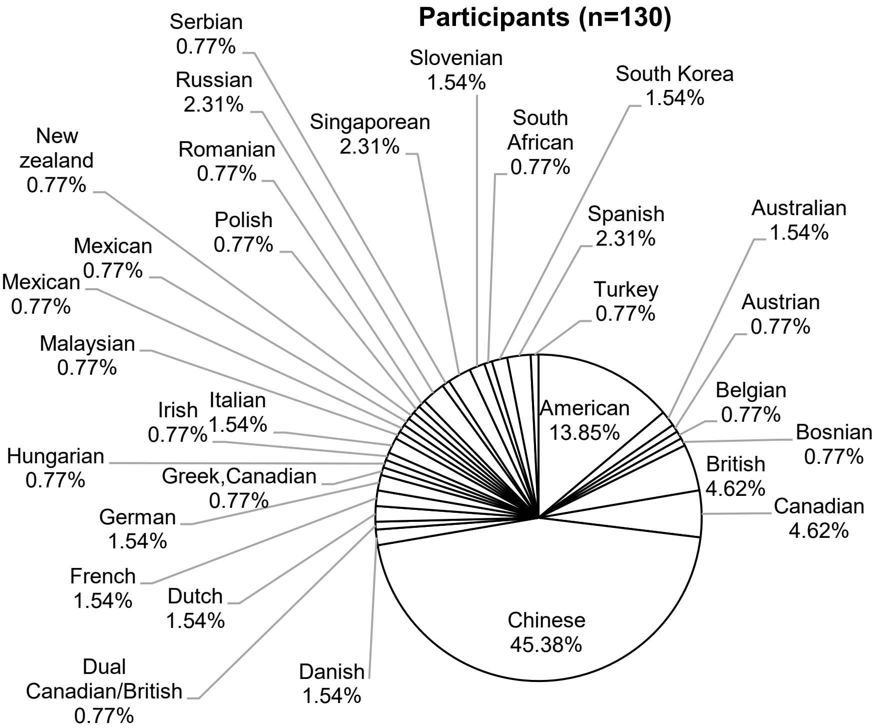
### Q1. What is your gender?



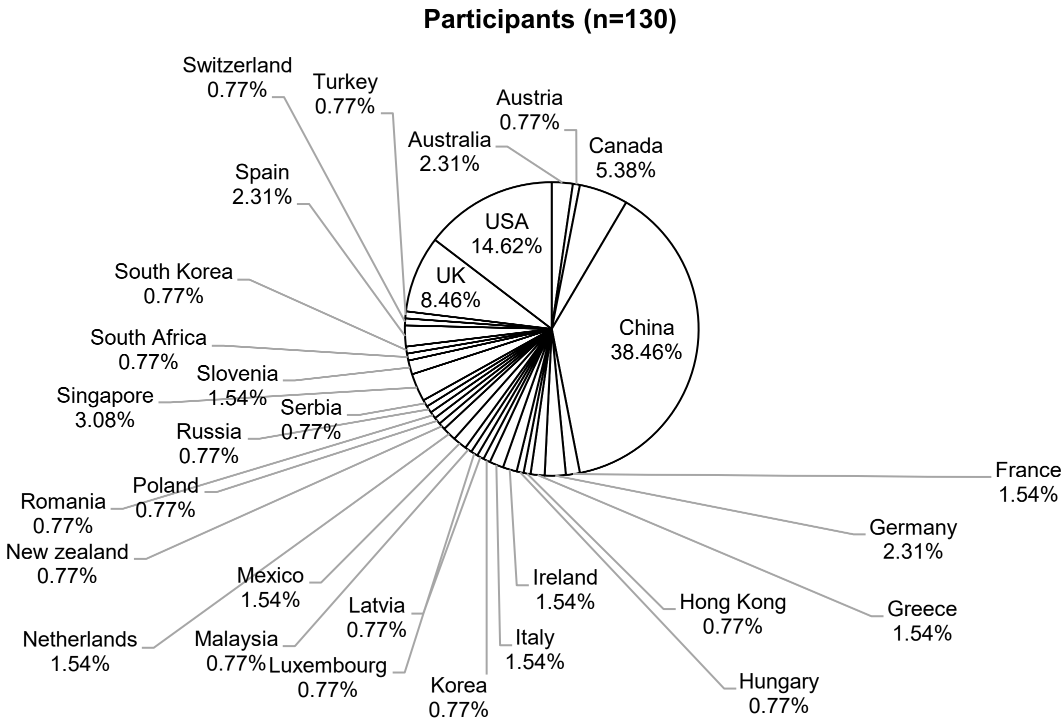

### Q2. What is your age group?



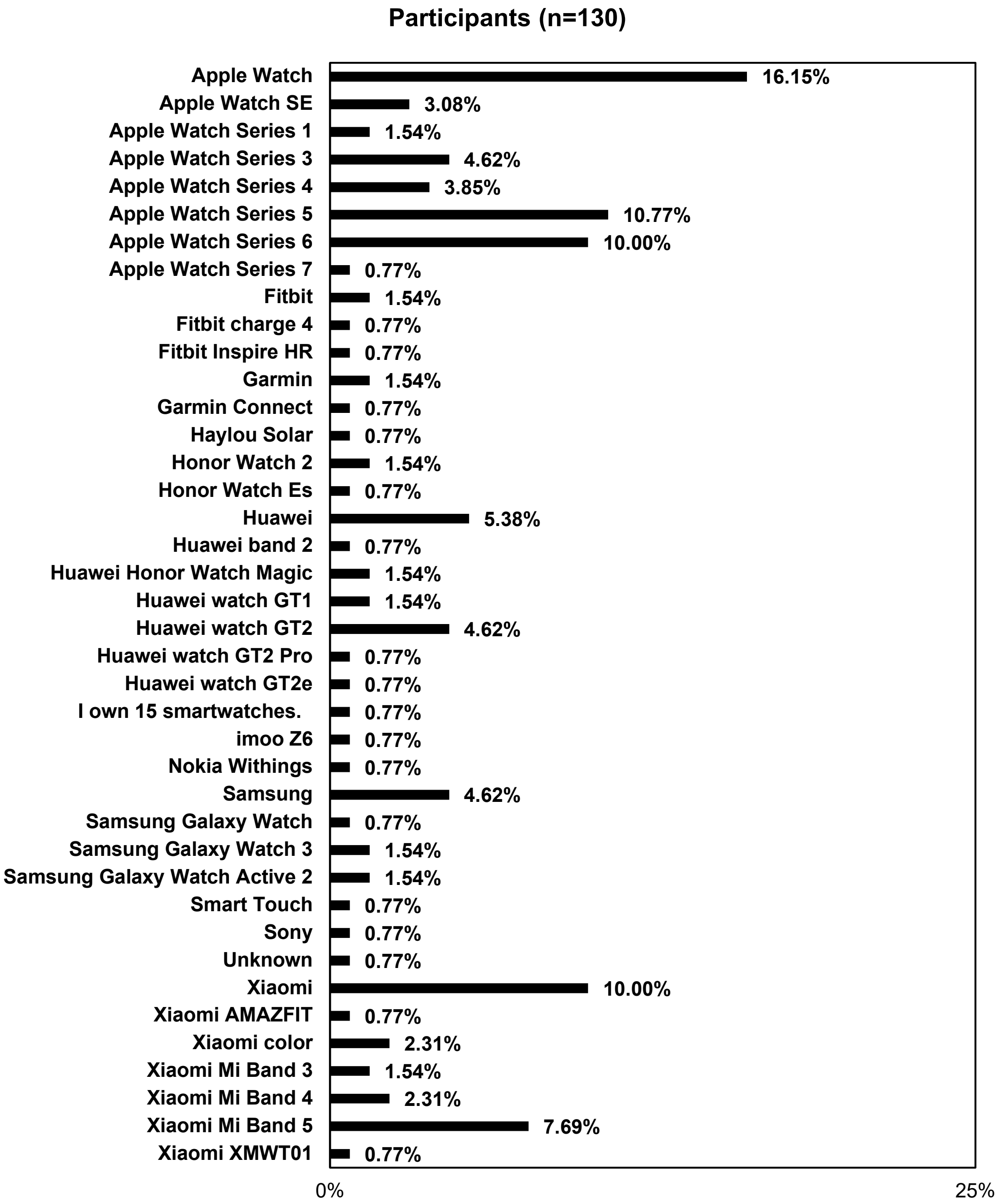
**Q3. What's your nationality?**



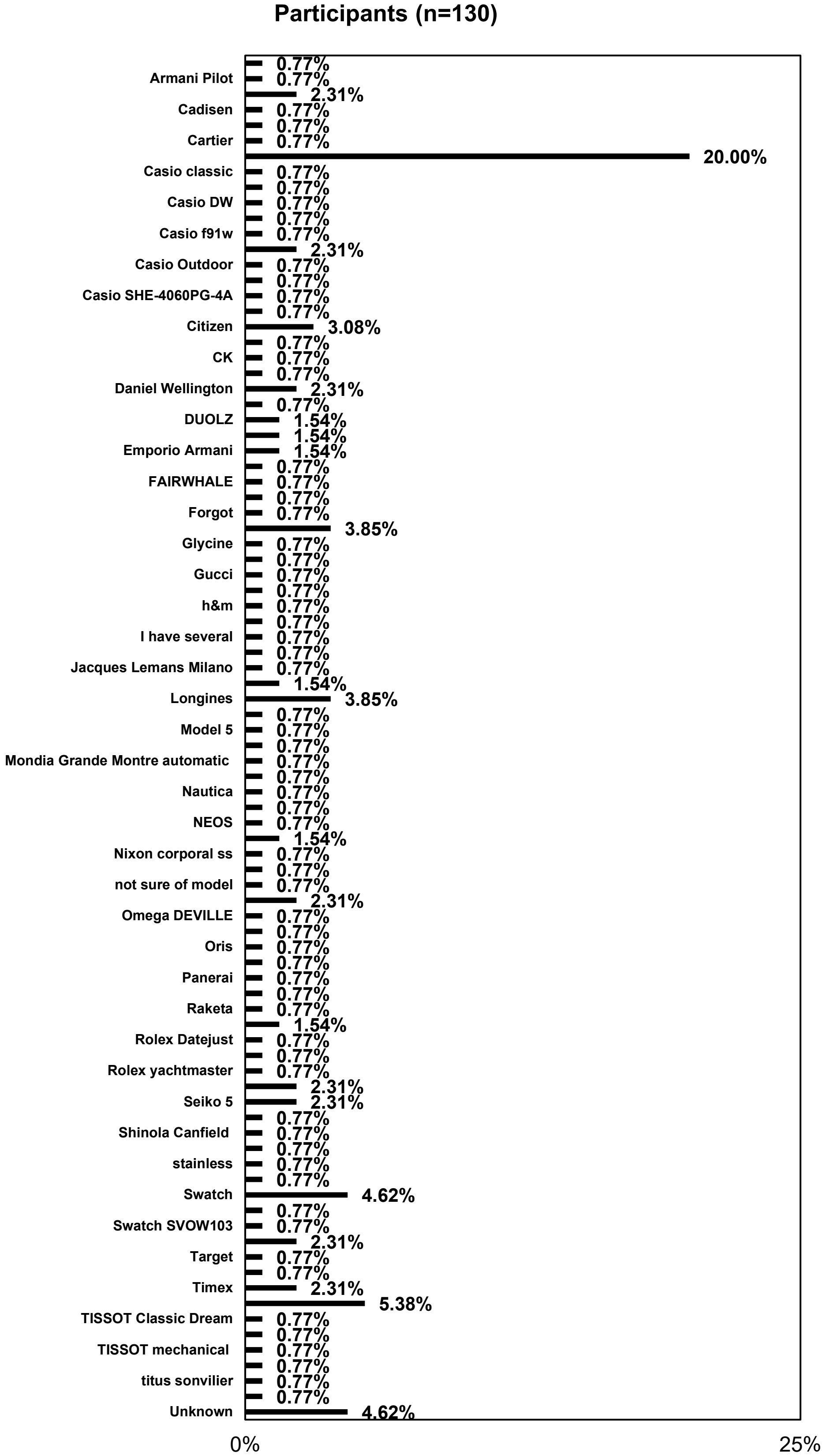

**Q4. Which country are you currently living in?**



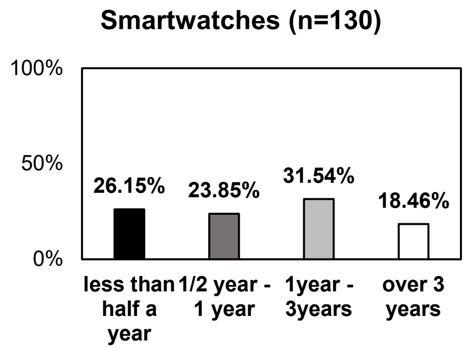
**Q5. What is the brand(s) and the model(s) of your SMARTWATCH(ES)? (You may find it on the back of your watch)**

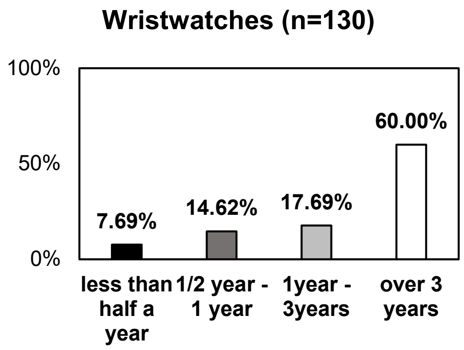


**Q6. What is the brand(s) and the model(s) of your WRISTWATCH(ES)? (You may find it on the back of your watch)**



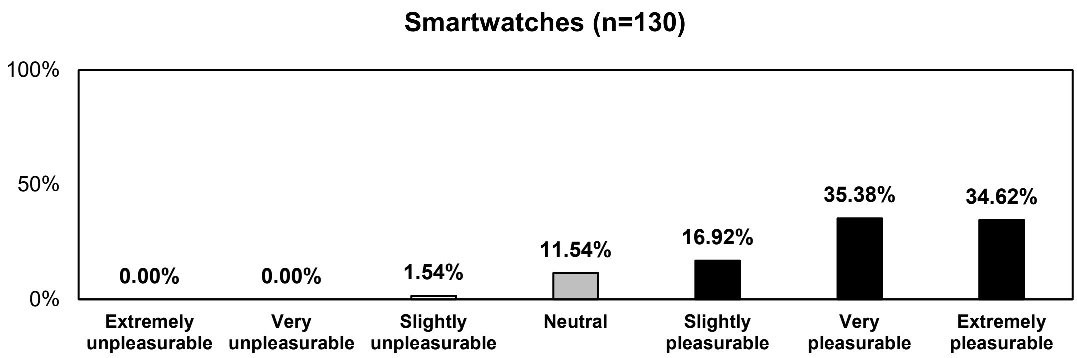
**Q7. How long did you use your SMARTWATCH(ES)you're your WRISTWATCH(ES)?**

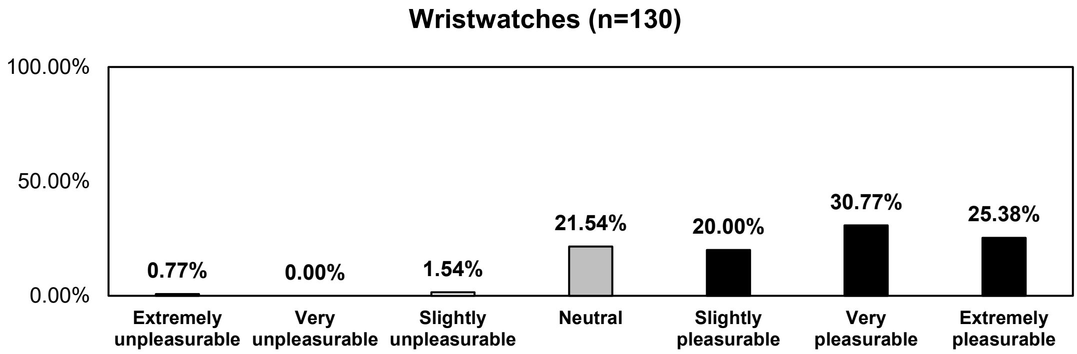



## Part 2. Pleasurable experiences of Smartwatches and Wristwatches

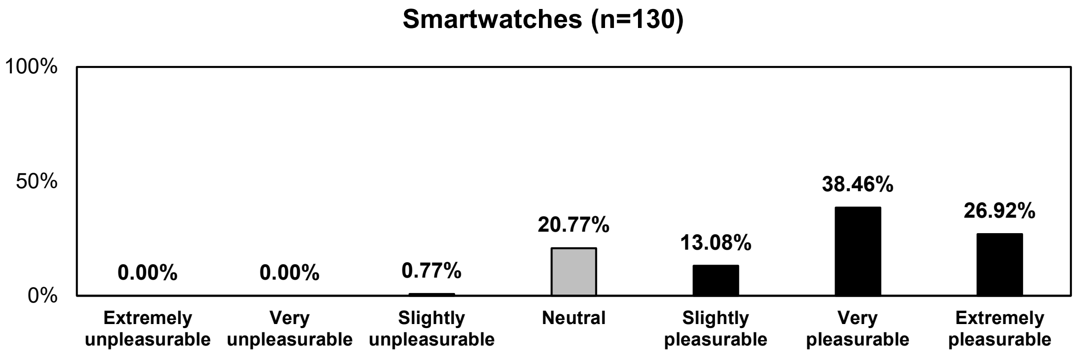
**Q9. [Physio-pleasure] How would you rate the experiences of touch during the interaction with your SMARTWATCH(ES) and WRISTWATCH(ES)?**

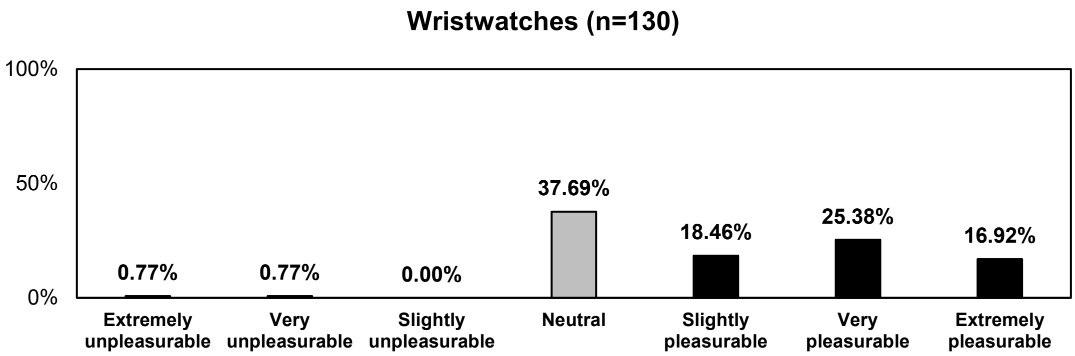


| Physio-pleasure | Smartwatches | Wristwatches |
|---|---|---|
| **Mean** | 1.900 | 1.538 |
| **SD** | 1.055 | 1.202 |
| **Variance** | 1.105 | 1.433 |
| **t-test (p)** | 0.011 | |

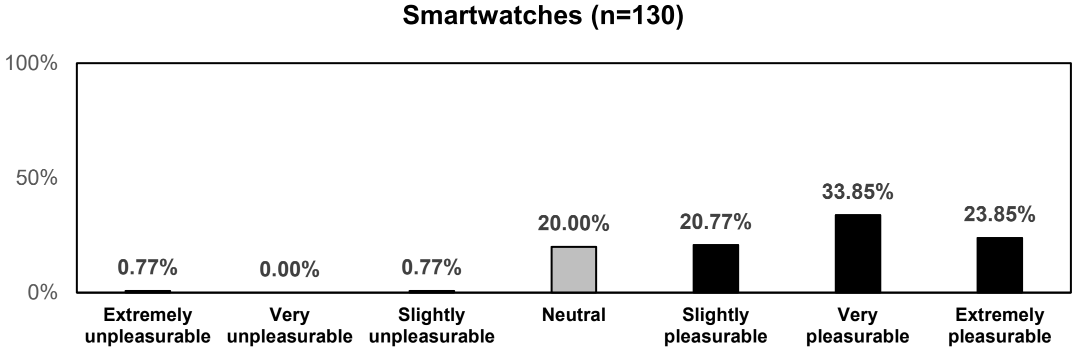
**Q10. [Socio-pleasure] Please rate the enjoyment of using your SMARTWATCH(ES) and WRISTWATCH(ES) in a social context, i.e. the enjoyment derived from relationships with others such as friends, loved ones, colleagues or likeminded people.**

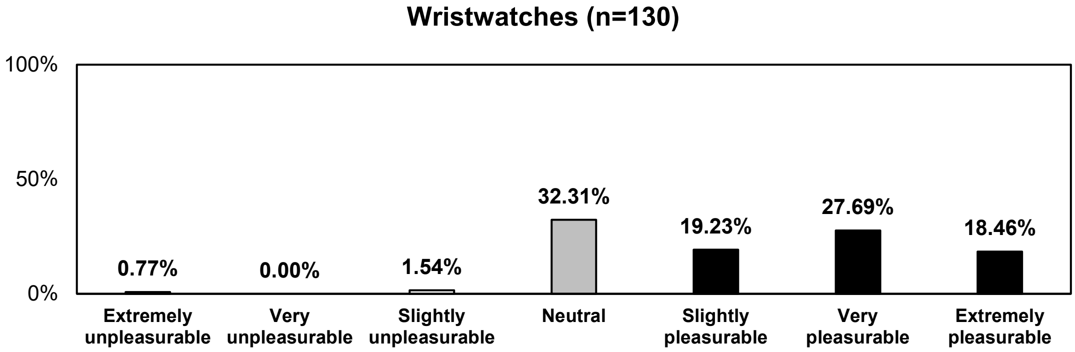



| Socio-pleasure | Smartwatches | Wristwatches |
|---|---|---|
| **Mean** | 1.700 | 1.162 |
| **SD** | 1.104 | 1.219 |
| **Variance** | 1.210 | 1.474 |
| **t-test (p value)** | <0.001 | |

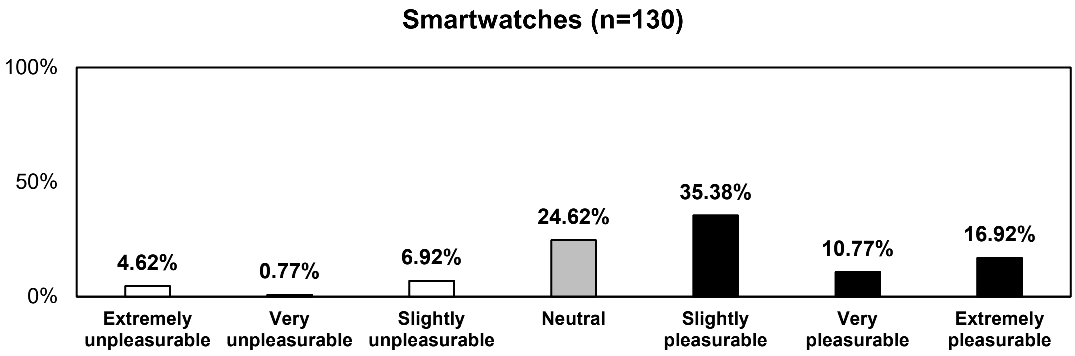
**Q11. [Psycho-pleasure] Please rate how your SMARTWATCH(ES) and WRISTWATCH(ES) affect your overall emotional and state of mind.**

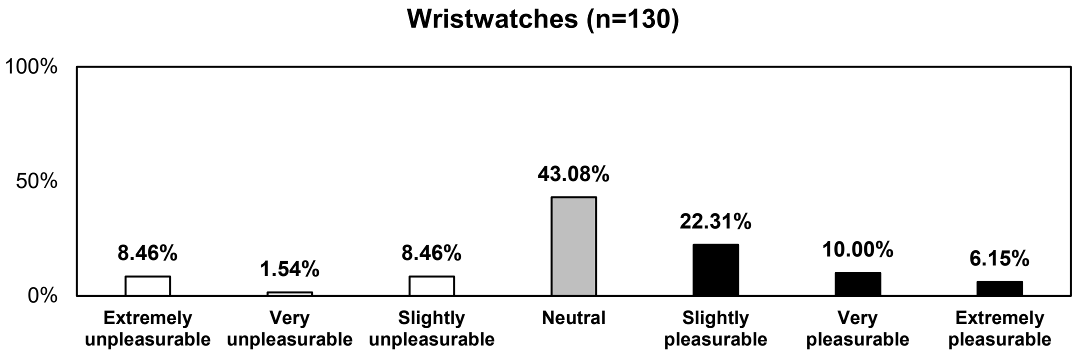



| Psycho-pleasure | Smartwatches | Wristwatches |
|---|---|---|
| **Mean** | 1.569 | 1.262 |
| **SD** | 1.154 | 1.211 |
| **Variance** | 1.322 | 1.455 |
| **t-test (P value)** | 0.037 | |

**Q12. [Ideo-pleasure] Please rate how your SMARTWATCH(ES) and WRISTWATCH(ES) affect your feelings about your personal goals and personal values.**

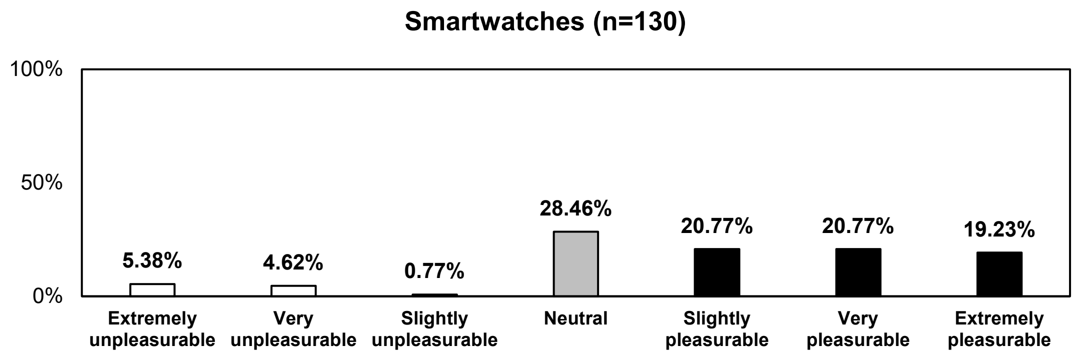


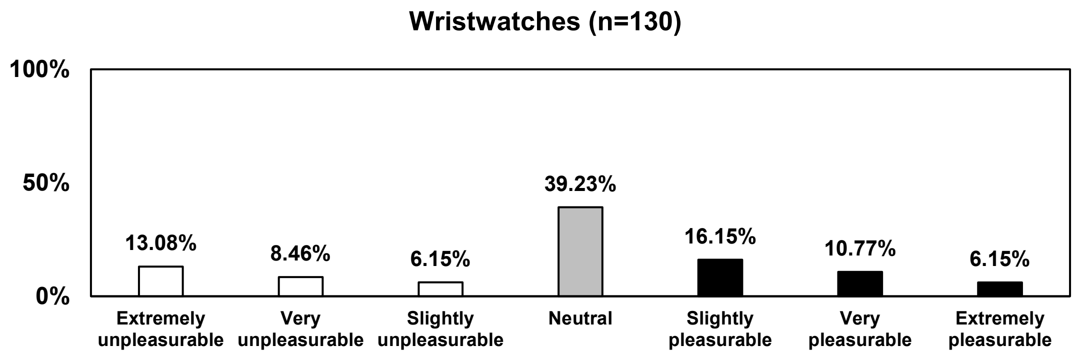




| Ideo-pleasure | Smartwatches | Wristwatches |
|---|---|---|
| **Mean** | 0.854 | 0.238 |
| **SD** | 1.453 | 1.430 |
| **Variance** | 2.094 | 2.028 |
| **t-test (P value)** | 0.001 | |

**Q13. Please rate how your SMARTWATCH(ES) and WRISTWATCH(ES) affect your thinking and emotions, in relation to each of the aspects below.**

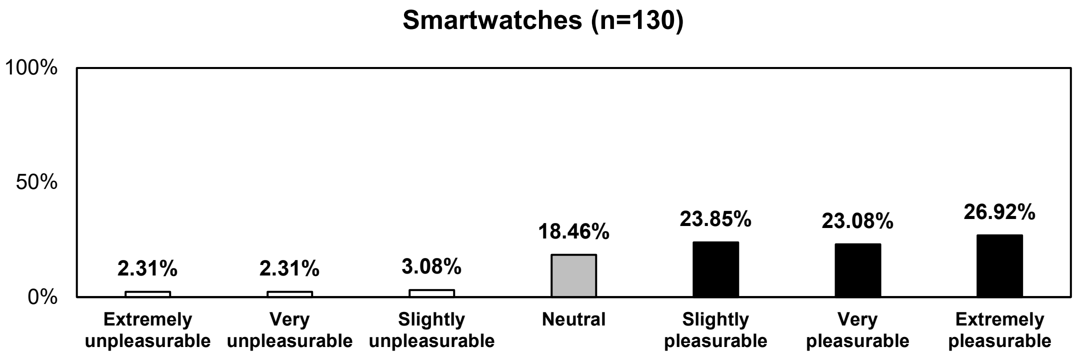
**[Relatedness] Having regular intimate contact with people who care about you**

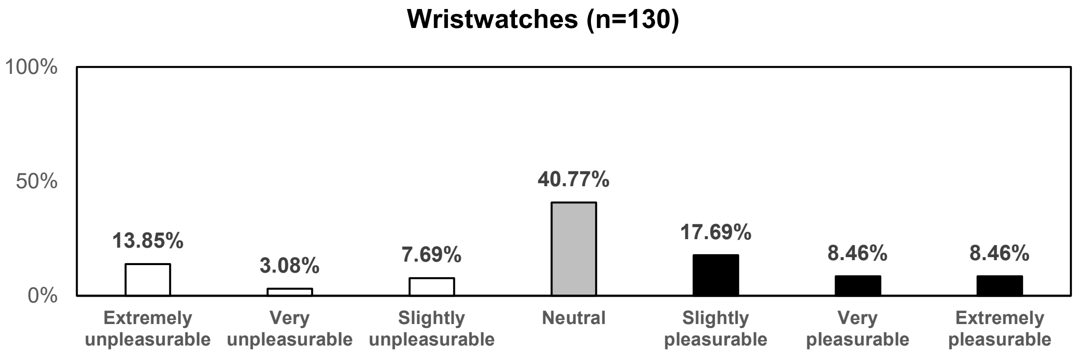



| Relatedness | Smartwatches | Wristwatches |
|---|---|---|
| Mean | 0.938 | -0.062 |
| SD | 1.608 | 1.655 |
| Variance | 2.565 | 2.719 |
| t-test (P value) | <0.001 | |

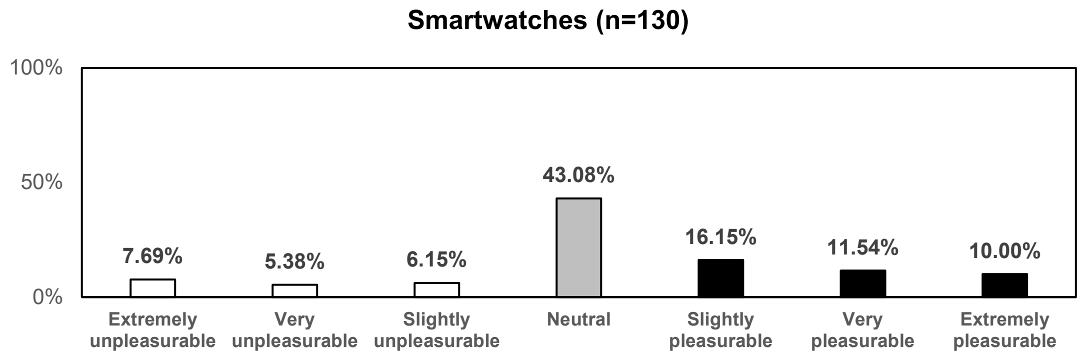
## [Stimulation] Getting plenty of motivation and stimulation

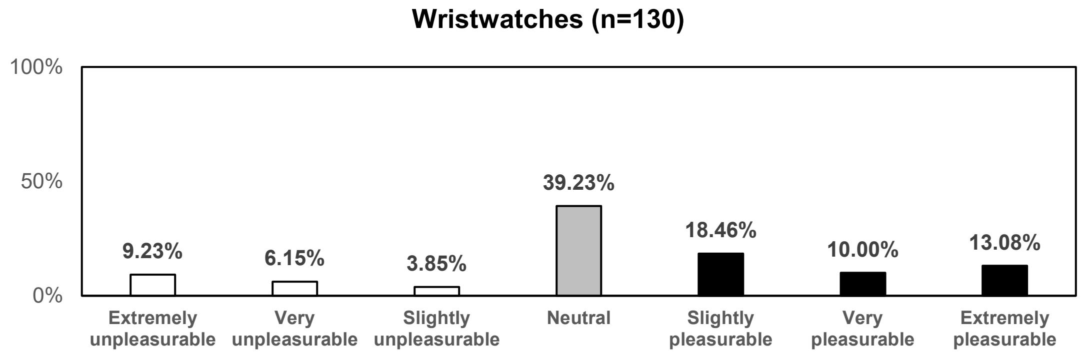



| Stimulation | Smartwatches | Wristwatches |
|---|---|---|
| **Mean** | 1.362 | 0.046 |
| **SD** | 1.441 | 1.656 |
| **Variance** | 2.062 | 2.721 |
| **t-test (P value)** | <0.001 | |

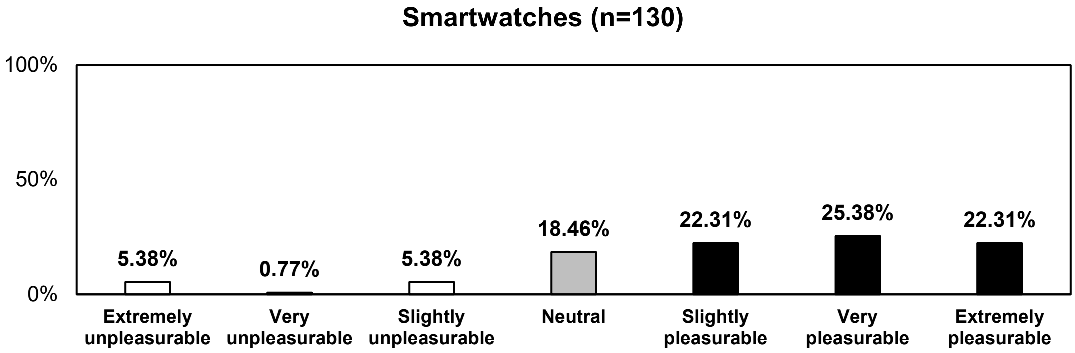
## [Popularity] Being liked, respected, and have influence over others

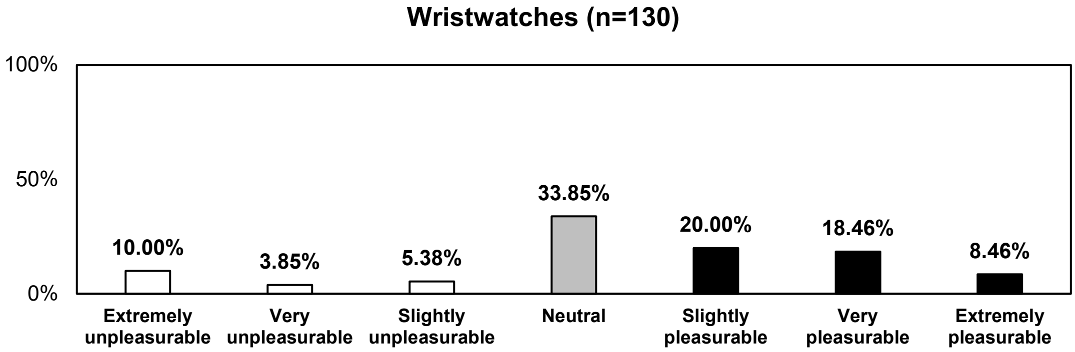



| Popularity | Smartwatches | Wristwatches |
|---|---|---|
| **Mean** | 0.292 | 0.338 |
| **SD** | 1.557 | 1.668 |
| **Variance** | 2.407 | 2.762 |
| **t-test (P value)** | 0.818 | |

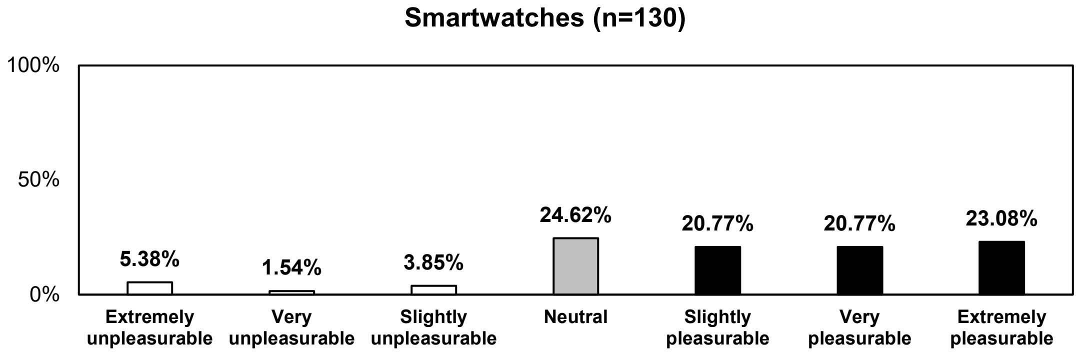
**[Competence] Being capable and effective in your actions**

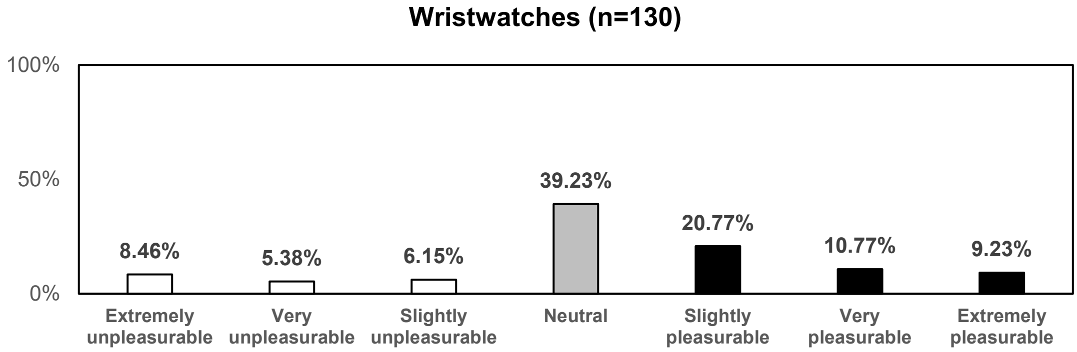



| Competence | Smartwatches | Wristwatches |
|---|---|---|
| **Mean** | 1.169 | 0.392 |
| **SD** | 1.571 | 1.635 |
| **Variance** | 2.448 | 2.654 |
| **t-test (P value)** | <0.001 | |

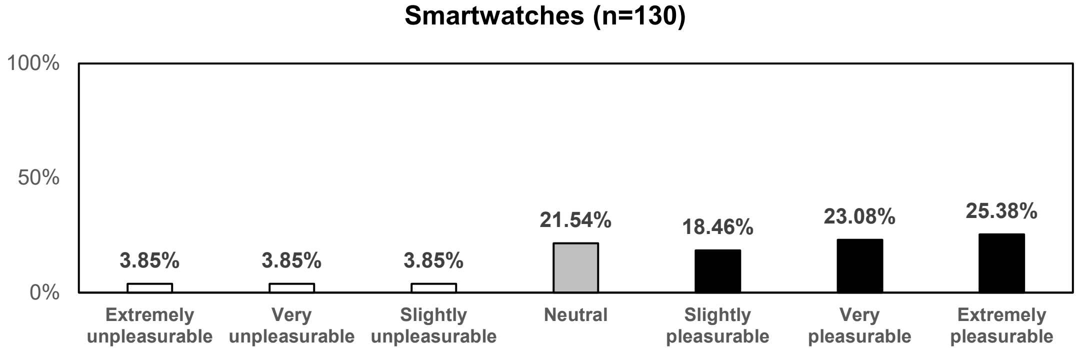
## [Meaning] Developing your best potential and making life meaningful

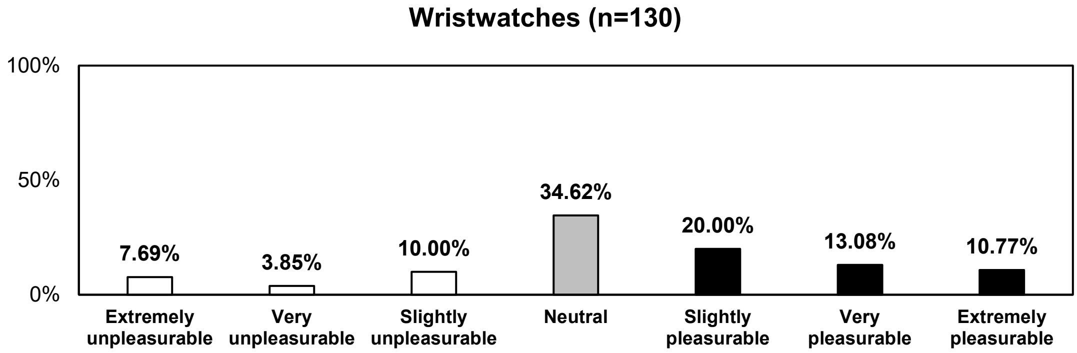



| **Meaning** | **Smartwatches** | **Wristwatches** |
|---|---|---|
| **Mean** | 1.085 | 0.277 |
| **SD** | 1.595 | 1.565 |
| **Variance** | 2.524 | 2.431 |
| **t-test (P value)** | <0.001 | |

**[Security] Feeling safe and in control of your life**




| Security | Smartwatches | Wristwatches |
|---|---|---|
| **Mean** | 1.177 | 0.377 |
| **SD** | 1.602 | 1.586 |
| **Variance** | 2.546 | 2.496 |
| **t-test (P value)** | <0.001 | |

**Q14. Do you have other opinions about the experiences of using SMARTWATCH(ES) and WRISTWATCH(ES) in terms of their enjoyment?**

| Participant ID | Answer |
|---|---|
| **P3** | no more |
| **P7** | I just like watches, smart or otherwise. |
| **P9** | I think people who buy wristwatches do so, not because they use them to tell time but because they're people who appreciate the intricate details of tiny clockwork mechanics.<br><br>Whereas people who buy smartwatches are more interested in functionality, data visualisation as well as automating more of data |

| | |
|---|---|
| | collection in terms of their health into something that can be meaningfully interpreted. |
| **P11** | Wristwatches have durability unless it has damage. However, the performance of smartwatches is highly sensitive to trends and the latest tech. |
| **P13** | The appearances of smartwatches need to be improved. |
| **P18** | I suggest the smartwatches increase their storage and battery life. Wristwatches don't have too many functions. I suggest smartwatches to add projecting screen function then there would be more parents bought for their children. Also, please introduce more popular apps and increase the battery capability. |
| **P19** | Sometime iwatch can distract my focus on study. |
| **P20** | as long as I like it, improve the after sale service |
| **P23** | Add more games on smartwatches |
| **P29** | Watches are difficult to bring social experience. New generations lauch really fast but no radical changes |
| **P30** | light-weighted and water-proofed, smartwatches don't need to have too many functions unless it can protect to a screen. |
| **P31** | Smartwatch might replace mobile phone in more occasions and wristwatch might replace more accessories. |
| **P32** | Improve entertainments of smartwatches, the aesthetic style of wristwatch can be more personalised. |
| **P37** | It would be great if the smartwatch can connect to Bluetooth Earphones. Self-assembled wrist band could be added to smartwatches |
| **P41** | This questionnaire reminds me of playing Draw Something on smartwatch with a friend but novelty effect disappeared very soon and it is not so enjoyable. Consuming time on mobile phone has already made me worrying. The smartwatch might be more distractive and I always think why I need it when I didn't use it. I told myself: it is just a watch. Sometimes setting a timer on my smartwatch could be annoying because I am in a quiet environment. I don't type on my smartwatch with voice assistant or make phone calls. Typing on it is not really ergonomics. |

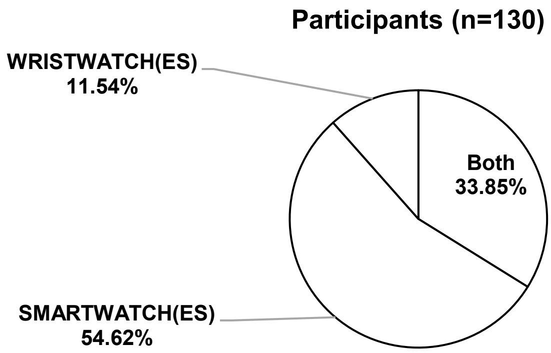
| | |
|---|---|
| | Wristwatches did everything when I need it and it is efficient and effective and it is also water-proofed. |
| **P43** | It’s too tired to wear smartwatches. virtual watches |
| **P45** | Look better and easier to wear |
| **P47** | Smartwatch might increase more entertaining functions/ design for the general public |
| **P48** | improve the connection between watches and humans, improve the sensory design of wristwatches |
| **P52** | good-looking |
| **P56** | Hope smartwatches can be more comprehensive and more friendly to old people. |
| **P59** | voice assistant, material and weight |
| **P60** | prefer wristwatches. I used mobile phone more often in daily life so I used smartwatches less. |
| **P61** | Wristwatch could be more personalised in customization. |
| **P63** | Both of them have good user experience. Smartwatches are more fresh and I also feel happy when I buy these wristwatches I like. Wristwatches have simple functions but have really good build quality. My friends who are more objective and calm prefer fancy wristwatches. I personally prefer smartwatches because it has better potentials. Young generations with active thoughts would prefer smartwatches. |
| **P64** | The smartwatch has more fun. Wristwatches have better stability |
| **P66** | Smart watches another distraction traditional watches is an art and so screen |
| **P72** | I am constantly amazed and delighted by the capabilities and design of my Apple watch. Smartwatches are a natural evolution of wristwatches and are better suited to the needs of modern users. |
| **P73** | I like the customisation of Watch faces that the Apple Watch offers. The battery life is often criticised by people but it has never been an issue for me. I charge the watch overnight, doubling it as a bedside clock and alarm. |
| **P75** | The main benefit of a smart watch for me is never having to adjust the time. But on the other hand smart watch requires charging it |

| | |
|---|---|
| | frequently |
| **P76** | I find smartwatches more enjoyable when I can fine-tune the information that I am getting on it. |
| **P79** | I enjoy my Smartwatch very much |
| **P82** | I started using smartwatches with the FitBit Charge 3, which is really more like a fitness tracker with some modest smart features. It will give you basic notifications, like for text messages, but it's really mostly for fitness and sleep tracking. While this is useful, I have been much happier with the Apple Watch because it can do all those things, plus serve as my sole communication device while I'm out. |
| **P84** | Would enjoy smart watch more if it had better third party apps |
| **P94** | It might be important to differentiate between smartbands (limited functions, huge battery life, inexpensive, non-watch look) and smartwatches (extra functions, short battery life, expensive, watch-looking). I use a smartband and a wristwatch, but would not use a smartwatch and a wristwatch. |
| **P95** | I get that both could be considered status symbols but generally what I wear doesn't affect my feelings and emotions that much. I am currently using my first smartwatch and it's in a band form factor, it's more comfortable especially during sport or sleep but it lacks some of the features of bigger models. I am interested in trying out different options but I am currently satisfied with it. |
| **P106** | I take pleasure in the mechanics of wristwatches. I am aware of the various movements, design history, and so froth. George Daniels is someone whose work I greatly admire. Smart watches please me in capability, and the spectacular amount of technology they bring to bear on daily activities. I had a Garmin 235 for several years and recently upgraded to the AppleWatch 6. I am very pleased with the screen and the wider set of stats that the AppleWatch can manage. |
| **P110** | Miss wearing a wristwatch |
| **P118** | My smart watch helps me be providing information in different situations. You can make a bigger statement with a expensive flashy wrist watch but I don't care about that. I started with the Android Wear Moto360 then I switched to Apple and I've been using the Apple Watch ever since. I'll stick with the Apple Watch as |

| | |
|---|---|
| | long as I'm an iPhone user. As Steve Job would say "It just works." Compared to Android Wear, it has better battery life, you don't need a bunch of 3rd party apps, it gets new features through updates, and etc... |
| **P119** | still on smartwatch learning curve; just got GT2 Pro watch with big face - easy to read texts and extremely beautiful as jewelry. Previous smartwatches very buggy and fussy and short-lived. Am hopeful. |
| **P130** | Smartwatches are fun to use. I like the look of wristwatches better, but enjoy using smartwatches more. |

## Part 3. Overall Experience

### Q15. Which kind of watch are you currently using?




### Q16. Please give reason why you abandoned SMARTWATCH(ES)/WRISTWATCH(ES) or why you are using both.

| Participant ID | Answer |
|---|---|
| **P1** | I only use smartwatch because I want to record my steps. |
| **P3** | Charging is troublesome |
| **P4** | Smartwatch contains multiple functions especially it can set reminder. |
| **P5** | Smartwatch provide more functionality |
| **P6** | I like it |
| **P7** | Variety, Mood |

| | |
|---|---|
| **P8** | I have stopped wearing my wristwatches because they don't offer as much functionality as smart watches. The only downside is that I have to keep it charged and of course, after a few years, it will get outdated and the battery is degraded. |
| **P9** | I have stopped wearing my wristwatches because they don't offer as much functionality as smart watches. The only downside is that I have to keep it charged and of course, after a few years, it will get outdated and the battery is degraded. |
| **P10** | I mainly use smartwatches except when I'm in a place where I cannot use them (e.g. Exams) |
| **P11** | I think it's because I'm used to the traditional purpose of the watch, like just checking the time. |
| **P12** | It is bothering to charge |
| **P14** | The smartwatch has more functions. I was only allowed to wear the wristwatch when I take an exam. |
| **P17** | Wear them on different occasions. |
| **P18** | I hope to use both of them and the build quality of the smartwatch to be improved. |
| **P19** | The smartwatch has more features |
| **P20** | They both have advantages. |
| **P21** | There are some occasions I need to check time on watch |
| **P23** | I have to wear wristwatch when meet some important people. |
| **P24** | Functions of smartwatches are more powerful and diverse. |
| **P25** | Make life easier |
| **P28** | my habit |
| **P29** | They have different features. Choose the suitable watch on the suitable occasion |
| **P30** | convenient to make phone calls and I don't have to take my mobile phone while working out |
| **P31** | I used both depending on the occasion. Sometimes I need the smartwatch and sometimes I need the wristwatch. |
| **P32** | Switching watch to wear makes me feel fresh. |
| **P33** | More features, convenient |
| **P34** | Charging is bothering and it looks terrible. |
| **P35** | The functions of the wristwatch is too simple and they cannot fulfil my needs. |
| **P36** | Smartwatches need to be charged often but wristwatches don't. |

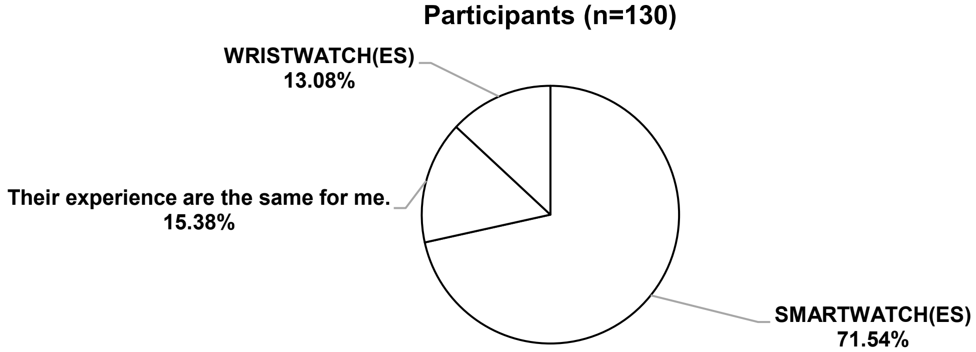
| | |
|---|---|
| **P37** | Wristwatch cannot track data. |
| **P38** | Both have different advantages but wristwatches can be used as accessories to match different clothes. |
| **P39** | I used both of them. |
| **P40** | Overall smartwatches are not useful enough and not really decorative. |
| **P41** | The experiences of apps like music player, timer and calendar on the smartwatches are not as good as on the mobile phone. The screen of the smartwatch is too tiny and I always have to raise my arm when I use it which is super annoying. The health data it recorded are not reliable as I don't like to wear any watch when I play sports. Also, it cannot be used individually without the mobile phone. I still have to take my mobile phone with me. The case of the smartwatch is thick and heavy. Setting up a timer on my casio watch is much easier than doing it on my apple watch. |
| **P43** | I don't wear a watch. It's not comfortable to wear a watch and it is bothering |
| **P44** | The functions are too simple compared to smartwatches |
| **P45** | I like the appearance of the wristwatch and features of the smartwatch. |
| **P46** | I personally believe that my smartwatch can completely replace my wristwatch. |
| **P47** | It is more convenient and fits more occasions |
| **P48** | Price and quality |
| **P49** | It is difficult to wear and take off |
| **P51** | Only need my watch to check time. |
| **P52** | Switching watch to wear makes me feel fresh. |
| **P55** | The functionality and the convenience of smartwatches are much better than wristwatches. |
| **P56** | I need both of them at the moment |
| **P57** | Compared to the wristwatch, the smartwatch has more functions. |
| **P58** | The smartwatch has better features. |
| **P59** | battery life and the accuracy of the time |
| **P60** | I always use my mobile phone |
| **P61** | bothering to charge |
| **P62** | Beautiful as accessories |
| **P63** | Switching watch to wear can switch my mood |

| | |
|---|---|
| **P64** | The smartwatch monitor the changes of my body index which benfits for exercising and wearing. The functionality of the wrsitwatch is simple which makes it more suitable to use at work. |
| **P65** | Because I have my mobile phone. |
| **P66** | I love a traditional watch, I dont like radiation withings is a perfect hybrid no screen or charge. I just need a sleep and step and maybe heart tracker in one. The element s of a traditional watch are irreplaceable but can be innovated. |
| **P67** | My wristwatch is classic leather and gold,  much smaller. Better for formal things. |
| **P68** | Very rarely wear a wristwatch - maybe if I went out in the evening. |
| **P69** | It depends on whether I'm at work or leisure |
| **P70** | Because smartwatches look better and are more useful |
| **P71** | Ditched wristwatch due to lack of modern functionality |
| **P72** | Apple watch is more versatile in the digital era |
| **P73** | I have no need for a normal watch now that I have my Apple Watch, and want to keep my rings going. |
| **P74** | Smartwatches are more than just watches, they are extension to your phone |
| **P76** | Found smartwatches more useful for myself. |
| **P77** | Switch on/off to take a break from tech |
| **P78** | Usefulness and QOL improvements offered by the smartwatch |
| **P79** | Cell phones made wrist watches are obsolete |
| **P80** | Smartwatch currently fills all needs of my wristwatch and more. |
| **P81** | I do not use smartwatches anymore because I always forgot to charge them which was annoying |
| **P82** | I prefer the greater functionality of smartwatches. Moving to the Apple Watch LTE allowed me to go out without my phone. I missed the days before we were all lugging around a phablet and it's nice to be free from it. |
| **P83** | Abandoned wrist bc they usually don't fit well and don't do enough (insufficient functionality) |
| **P84** | Lost my wristwatch, didn't want to get another one |
| **P85** | I find my Apple Watch to have more functionality |
| **P86** | Wristwatch is heavy |
| **P87** | Wristwatch does not provide enough functions |
| **P88** | See answer to Q. 14 |

| | |
|---|---|
| **P89** | Just got Apple Watch enjoy integration |
| **P93** | I would never wear a smartwatch to a formal event. But a smartwatch has replaced my need for a wristwatch entirely. The added functionality beats all, and even if it's not as visually pleasing, the very fact that I wear one makes it appear trendy and fashionable. |
| **P94** | I use only a basic smartwatch (Xiaomi Mi Band 5) when at home, for its functions. I use also a wristwatch and bracelets when I go out, as fashion accessories (in that case I use both the wristwatch and smartwatch). |
| **P95** | I am used to wristwatches and I like them but I also like the extra functions of smartwatches, I might get a hybrid one in the future. (Quartz movement with physical hands and a display) |
| **P96** | Abandoned wristwatch because smart watch does everything it does and more |
| **P97** | Depends on the itinerary of the day. Mostly smartwatch during COVID. |
| **P98** | I abandoned the wristwatch because my smartwatch gives me more information |
| **P99** | I like wristwatches for basic functions, and then use the fitness tracker for notifications and health tracking |
| **P100** | I largely abandoned wearing my wristwatches because they just couldn't compete with the feature set of an Apple Watch. |
| **P101** | Checking notifications without my phone |
| **P102** | More possibilities |
| **P103** | Because I got bored of my Casio. |
| **P104** | Needed a water resistant watch (last wristwatch broke from sweat during exercise) and smart watch gave added useful information (fitness tracking) |
| **P105** | Just bought Mi Band 2 and I liked it |
| **P106** | Mechanical watches couldn't handle the fitness metrics I wanted |
| **P107** | I originally only had a wristwatch. I use this all the time, at work and other places for time telling. I got the smartwatch for fitness tracking, sleep tracking, health tracking more than any other reason. |
| **P108** | Style, Automatic (wristwatch) & health monitoring (smartwatch) |
| **P109** | I got Skin irritation from my Wristwatch because of the Size |

| | |
|---|---|
| **P110** | Smart watches are practical for the times. |
| **P111** | I only use my smartwatch, because it has more features - I can do more things on the go. Also, I don’t carry my phone with me as much, because I can do most of the things I need on my smartwatch, and I don’t get distracted, because I don’t use social media apps on it, so it helps with my phone addiction. |
| **P112** | I prefer the bands on the Apple watch |
| **P114** | It still has all the functions as well as a lot more. |
| **P115** | They are dumb |
| **P116** | both because it depends on the circumstances. |
| **P117** | Got smartwatch |
| **P118** | I abandoned wristwatches because the smart watch does so much more. |
| **P119** | Sleep &walking tracking, texts |
| **P120** | I pretty much only wear my smart watch now unless I am going to a formal event where it would look out of place, then I wear my wristwatch |
| **P122** | One has more functionality, the other has more aesthetic appeal |
| **P123** | abandoned wristwatch cause the smartwatch has the same features but also so much more |
| **P124** | I stopped using my wristwatches (I have a dozen) because I like my smart watch MUCH more. |
| **P126** | Love functionality of smartwatch but love the look of a real high quality timepiece |
| **P128** | it depends on what I’m doing |
| **P129** | I have switched to a Smartwatch for step and sleep tracking. |
| **P130** | Wasn’t using wristwatches much before, like using smartwatches especially for exercising |

**Q17. Which type of watches provided you better overall experience do you think?**




**Q18. Please explain the reasons for your choice in the last question? (Why that type of watches provided you better user experience? or why do you think their experience are the same?)**

| Participant ID | Answer |
|---|---|
| **P1** | smartwatch has more functions. |
| **P3** | make my life more colorful |
| **P5** | Smartwatch allow me to keep tracking many things aside from date and time |
| **P7** | Smarter. More functions. More in line with modern life today. |
| **P8** | I've stopped wearing my wristwatches because they don't offer as much functionality as smart watches. The only downside is that I have to keep it charged and of course, after a few years, it will get outdated and the battery is degraded.<br><br>Smartwatches, on the other hand, provide so much more functionality. Furthermore, I'm not the kind of person that wears different watches for different occasions. I prefer to have one watch for all occasions so I'm currently using a stainless steel Apple Watch that is appropriate for the office yet stays in my wrist (with a different strap) for the gym. |

| | |
|---|---|
| **P9** | I've stopped wearing my wristwatches because they don't offer as much functionality as smart watches. The only downside is that I have to keep it charged and of course, after a few years, it will get outdated and the battery is degraded.<br><br>Smartwatches, on the other hand, provide so much more functionality. Furthermore, I'm not the kind of person that wears different watches for different occasions. I prefer to have one watch for all occasions so I'm currently using a stainless steel Apple Watch that is appropriate for the office yet stays in my wrist (with a different strap) for the gym. |
| **P10** | More convenient and functions (Anything a wristwatch does, a smartwatch can do and more) |
| **P11** | intuitive experience, durability |
| **P12** | Only focus on aesthetics. Like all the watches with good lookings. |
| **P14** | It has different functions and using purposes |
| **P16** | It is more convenient to watch messages |
| **P17** | Smartwatches supplied more functions to choose |
| **P18** | Smartwatches are still developing but luxury watch is a taste. |
| **P19** | Hard to determine it. But swatch has little features comparing to iwatch |
| **P20** | Easy to use. Read the information quicker. |
| **P21** | Wearing different kinds of watches in different occasions |
| **P23** | Smartwatches are modern and neat |
| **P24** | Smartwatches are able to watch time, use for navigation but wristwatches are not |
| **P25** | It is like a mobile phone. There are lots of thing I can do with it but smartwatch can only do a little things. |
| **P28** | could be used for studying |
| **P29** | It is able to monitor body index and make it easier to manage my body |
| **P30** | It is able to make phone calls. |
| **P31** | They are similar but they are used in different ocasions. They have different functions but both of them bring convenience to people. |
| **P32** | They are mordern and diverse |
| **P33** | More functions, portable, can be used for entertaining |
| **P34** | stable and elegant |

| | |
|---|---|
| **P35** | The smartwatch has more functions and it fulfills my needs better. |
| **P36** | Smartwatches have more functions like entertaining and making phone calls. It is convenient to go out with out the mobile phone. |
| **P37** | It is able to collect my body data and monitor my sleep. |
| **P38** | More functions More powerful |
| **P39** | Because it is smart. |
| **P40** | Dress code in the workplace. I don't need the functions on smartwatches. |
| **P43** | I don't like wearing watches. |
| **P44** | More functions |
| **P45** | I like the features of the smartwatch and the function of the wristwatch so I bought the both. |
| **P47** | It is more convenient to use the smartwatch. |
| **P48** | Touch screen, response quicker |
| **P49** | Smartwatches have more functions. |
| **P51** | mostly use to check time |
| **P52** | Wristwatches have more precise structure which make them looks more comfortable |
| **P54** | Smart. Functions like health track, sleep track and alarm are easy to use and I always use them. |
| **P55** | Smartwatches make the life easier and they got a sense of technology. |
| **P56** | Because the smartwatch has more functions which benefits all aspects of my life and it can also track my health, and it is easy to track elderly's health. |
| **P57** | Waterproof, good touch-feeling, many functions, good value |
| **P58** | The smartwatch has more functions and it is better for practical purposes. |
| **P59** | More functions, the colours are brighter |
| **P60** | I wore my wristwatch for longer time. Smartwatches are fresh for me. |
| **P61** | Smartwatches could influence my life more. |
| **P62** | check time and date |
| **P63** | It is fresher for me and it might have more possibilities. |
| **P64** | meet most of my requirements |
| **P65** | The main function of watch is watching time. |
| **P66** | I used a hybrid because I like the traditional watch with special |

| | |
|---|---|
| | features |
| **P67** | The smart watch is great for more information and self tracking but slightly controlling. The 'activity rings' on the apple watch can be very controlling as you feel like you have to fulfill them. The normal watch is just something you don't really notice. |
| **P68** | I can use the smartwatch to do so much more than a wrist watch. Maybe before I would have had to use another device to record my cycle journeys. |
| **P69** | You can control all the things around your live style |
| **P70** | The smartwatches just has way more features and is overall more useful |
| **P71** | My smart watch is good for professional situations as well as personal and health and fitness. Not to mention the obvious connectivity it provides which I find priceless. |
| **P72** | The Apple watch can do so much more than a wristwatch can, so the experience and enjoyment are multiplied. |
| **P73** | They provide so much information on your wrist without having to go to your phone. |
| **P74** | It's not just a watch, it's much more |
| **P75** | The main function is checking the time. While the extra features of a smart watch may be useful, they are extra and not needed most of the time. |
| **P76** | The smartwatches I have owned have expanded my capabilities when it comes to interacting with my other devices or friends and family as they offer new features to speed up day-to-day tasks and give me new methods of interaction (digital touch on Apple Watch and Walkie-Talkie Feature). |
| **P77** | Interactive |
| **P78** | More functionalities at the fingertips or through voice commands. Far superior to wristwatch + smartphone. |
| **P79** | My smart watch enhances my life. It keeps me connected and motivates me. |
| **P80** | Smartwatches just do a lot more in addition to telling the time. |
| **P81** | Because the wristwatch is rather neutral - it is an accessory - the smartwatch brought me a lot of negative feelings as well |
| **P82** | Smart watches do more, and in the case of the Apple Watch, do it quite smoothly these days. I think they're gotten to a good balance |

| | |
|---|---|
| | of functionality without being as distracting and overwhelming as a smartphone. |
| **P83** | It allows me to do more |
| **P84** | More functions. More connectivity |
| **P85** | I like my Apple Watch better because it has so many more functions that make my life better |
| **P86** | More function |
| **P87** | More functions in the same package |
| **P88** | Saves pulling out iPhone when I get notifications. Like many old people I'm clumsy and the Apple Watch saves me from the danger of dropping my phone and cracking its screen. |
| **P89** | Great for different reasons |
| **P93** | The added functionality makes up for it's lack in appearance. |
| **P94** | To me, wristwatches and smartwatches (smartbands) offer different attributes. One is about looks, fashion and ease of reading the time and date, and the other one is about the extra functions, and constant wear. |
| **P95** | Different goals and functions. |
| **P96** | They do more |
| **P97** | Depends on the context. At the gym, smartwatch is an amazing tool to track blood oxygen levels and heart rate; when fishing or outdoors, the wristwatch is perfectly legible (smartwatch hard to read in sun) and built to withstand salt water.<br><br>Basic example, but general gist is there. |
| **P98** | The information they provide |
| **P99** | Both are good for different things I guess. |
| **P100** | I've had nothing but relatively cheap wristwatches, so I think the precision and UX design by Apple of my smart watch just blows them out of the water. |
| **P101** | Much more information available on a smart watch, but a wristwatch can be more pleasurable to wear. The smart watch is just practical |
| **P102** | Offer more functions |
| **P104** | I want to use a watch (whether wrist or smart) as an unobtrusive time keeper that allows me to separate myself from my phone (ie not distracting, no notifications, etc). |

| | |
|---|---|
| **P105** | Smart functions, easy customization (bands,watchfaces etc.) |
| **P106** | At this point in my life, I am more focused on the metrics a smartwatch can provide than the pleasure I take in mechanical watches. |
| **P107** | They're NOT really the same at all. But you didn't have an appropriate option. So wristwatches are a jewellery and practical item of long standing. I grew up with them of course. They can make a statement about your personality. Smartwatches are also a bit of a fashion item and can look very nice. They have many more practical uses than a wristwatch of course. So they actually, for me anyway, perform different functions. |
| **P108** | Style, weight, size and better readable. Wish i could combine the two into one wristwatch. |
| **P109** | More features |
| **P110** | Ease of mind. No need to have phone on you. Tracks almost everything |
| **P111** | Smartwatches give me more ways to connect with people and accomplish my goals due to their functionality. |
| **P112** | All I really care about is the time. |
| **P114** | You can do a lot more with smartwatch |
| **P115** | Wristwatches only give time and time related things while a smartwatch gives you a whole lot of information including health data you can analize for bettering yourself |
| **P116** | Feeling connected all the time. |
| **P117** | More options |
| **P118** | A smart watch provides much more |
| **P119** | Walking & Sleep Tracking very important to me. |
| **P120** | Smart watches have more features and functionality |
| **P122** | More functionality, more intuitive to use, more interactions with it. |
| **P124** | It provides a lot more information than does a wristwatch. |
| **P126** | More functionality. Health tracking mainly |
| **P128** | Smartwatches are practical and multi-functions but nothing replace the beauty of a skeleton dial. |
| **P130** | more functions, enjoy using them for exercising |

# Appendix E. Workshops 1&2 Consent Form

Royal College of Art
RESEARCH & INNOVATION

**Participant Project Information & Consent Form**

(One signed copy of this form should be retained by the Participant and one copy by the Project Researcher)

*Workshop on Smartwatches as a Type of Internet of Things (IoT) Products and Their Pleasurable Experiences*

Supervisor: Dr Bjorn Sommer
*bjorn.sommer@rca.ac.uk*

*15/02/2021*

Dear Potential Participant,

*I am Zidong Lin a PhD student* in Design Research at the Royal College of Art. As part of my studies, *I am* conducting a workshop about Smartwatches as a kind of Internet of Things Products and their pleasurable user experience. You are invited to take part in this research project which explores the user experience of smartwatches and IoT products.

If you consent to participate, this will involve:
*A workshop with 4 activities which takes 2.5 to 3 hours. You will contribute your ideas and sketches in the workshop. The workshop will be organised virtually by online platforms Zoom and Miro. The process of the workshop will be recorded by Zoom after getting your permission.*

Participation is entirely voluntary. You can withdraw at any time up to the point of publication and there will be no disadvantage if you decide not to complete the study. All information collected will be confidential. All information gathered will be stored securely and once the information has been analysed all individual information will be destroyed.

Images or quotes, which may allow you to be identified will only be used with your express permission.

If you have any concerns or would like to know the outcome of this project, please contact my supervisor Dr Bjorn Sommer at the above address.

**Research Office** Royal College of Art Kensington Gore London SW7 2EU
t +44 (0)20 7590 4126 f +44 (0)20 7590 4542 research@rca.ac.uk www.rca.ac.uk/research

Thank you for your interest.

I *(please print)* ......................... have read the information above and all queries have been answered to my satisfaction. I agree to voluntarily participate in this research and give my consent freely. I understand that I can withdraw my participation from the project up to the point of publication, without penalty, and do not have to give any reason for withdrawing.

I understand that all information gathered will be stored securely, and my opinions will be accurately represented. Any data in which I can be clearly identified will be used in the public domain only with my consent.

Participant Signature.............................................

Researcher Signature..........................................................................

Date: ................................................................................

**Complaints Procedure:**

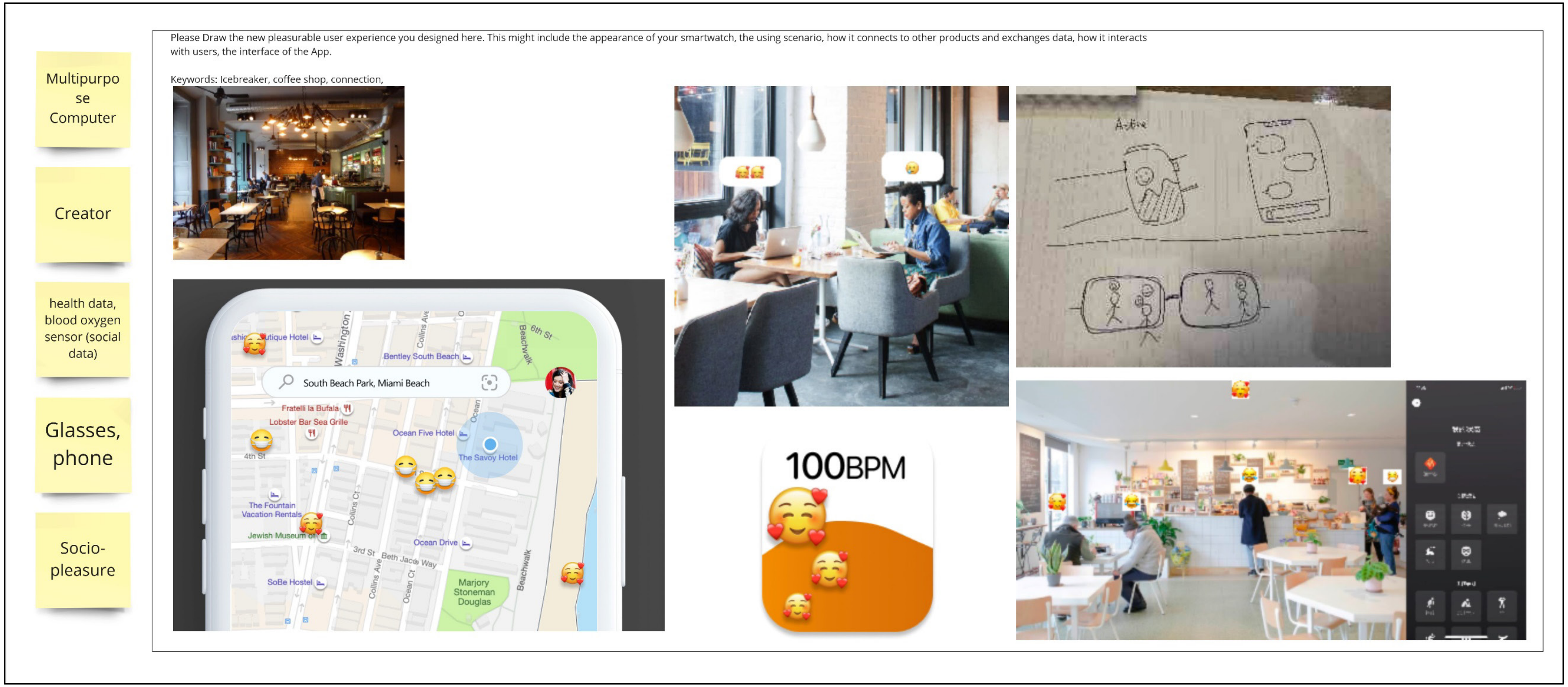
This project follows the guidelines laid out by the Royal College of Art Research Ethics Policy.

If you have any questions, please speak with the researcher. If you have any concerns or a complaint about the manner in which this research is conducted, please contact the RCA Research Ethics Committee by emailing ethics@rca.ac.uk or by sending a letter addressed to:

The Research Ethics Committee
Royal College of Art
Kensington Gore
London
SW7 2EU

# Appendix F. Workshop 1 Results

## Group1



## Group 2

Multipurpose computer

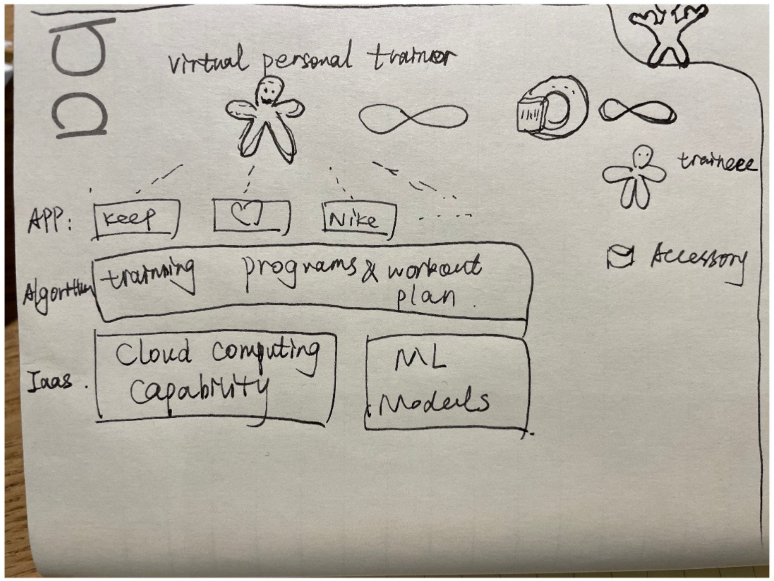
Collector, Actor, Creator

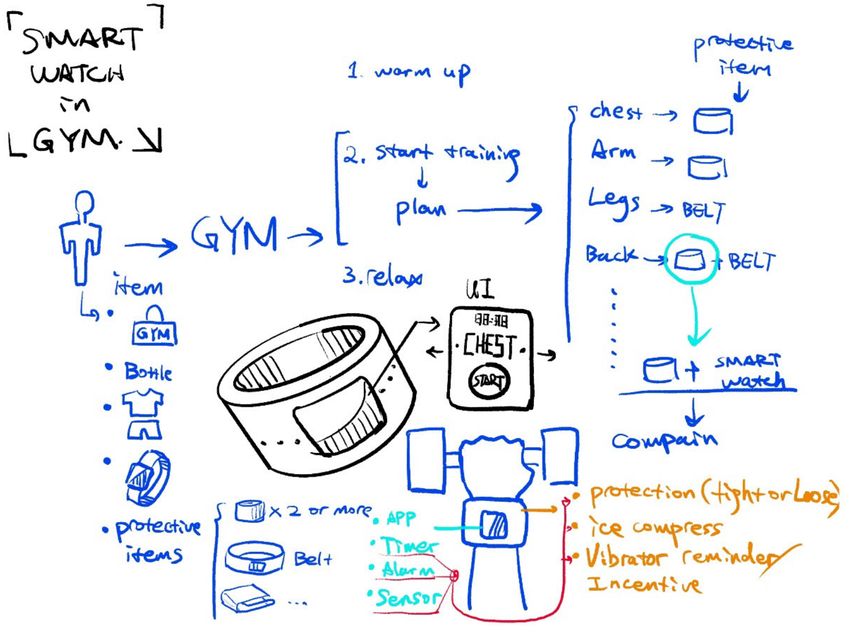
Professional sports data

protective item, APP like KEEP etc. , Human,

IDEO of pleasure

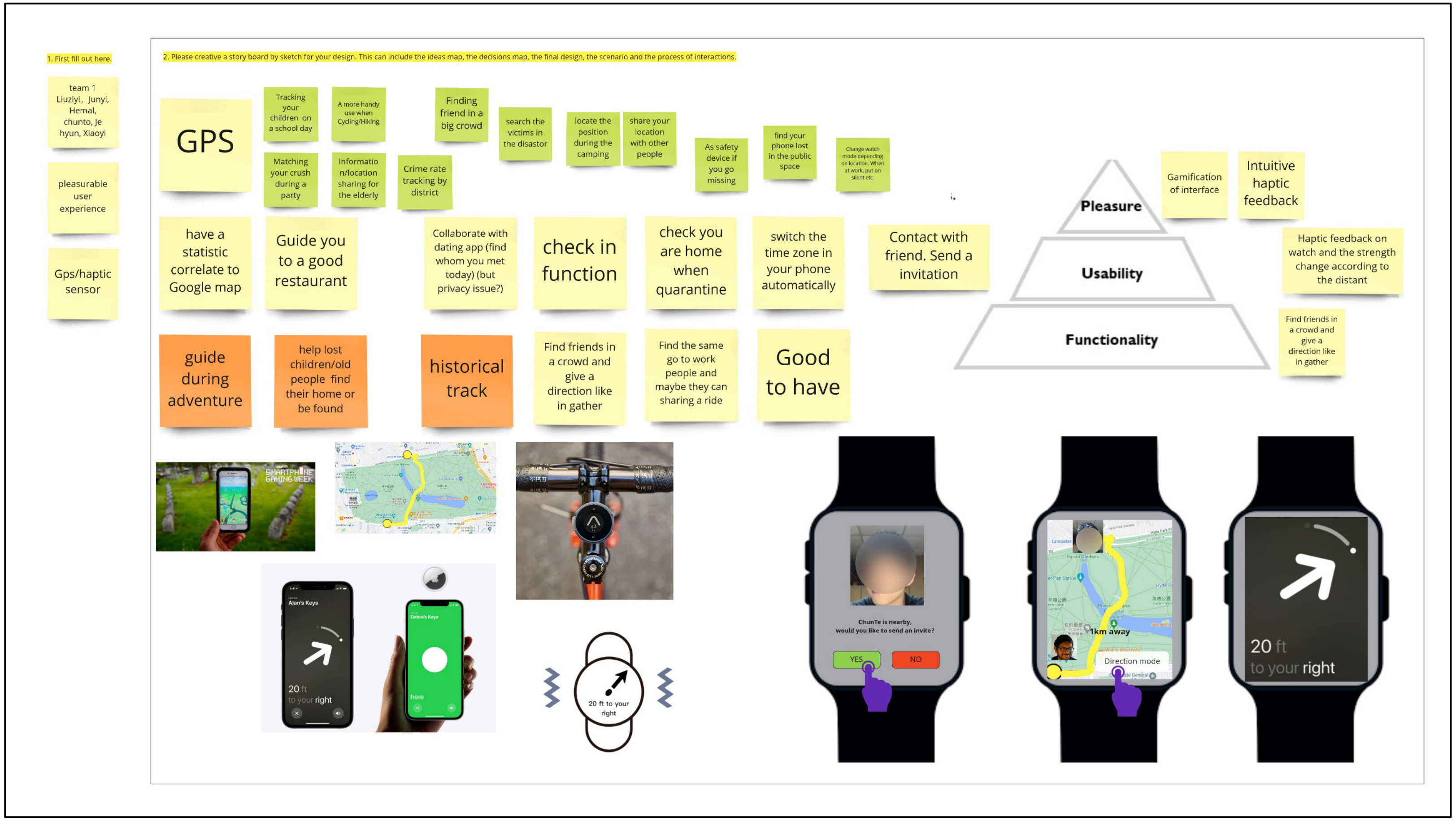
Please Draw the new pleasurable user experience you designed here. This might include the appearance of your smartwatch, the using scenario, how it connects to other products and exchanges data, how it interacts with users, the interface of the App.



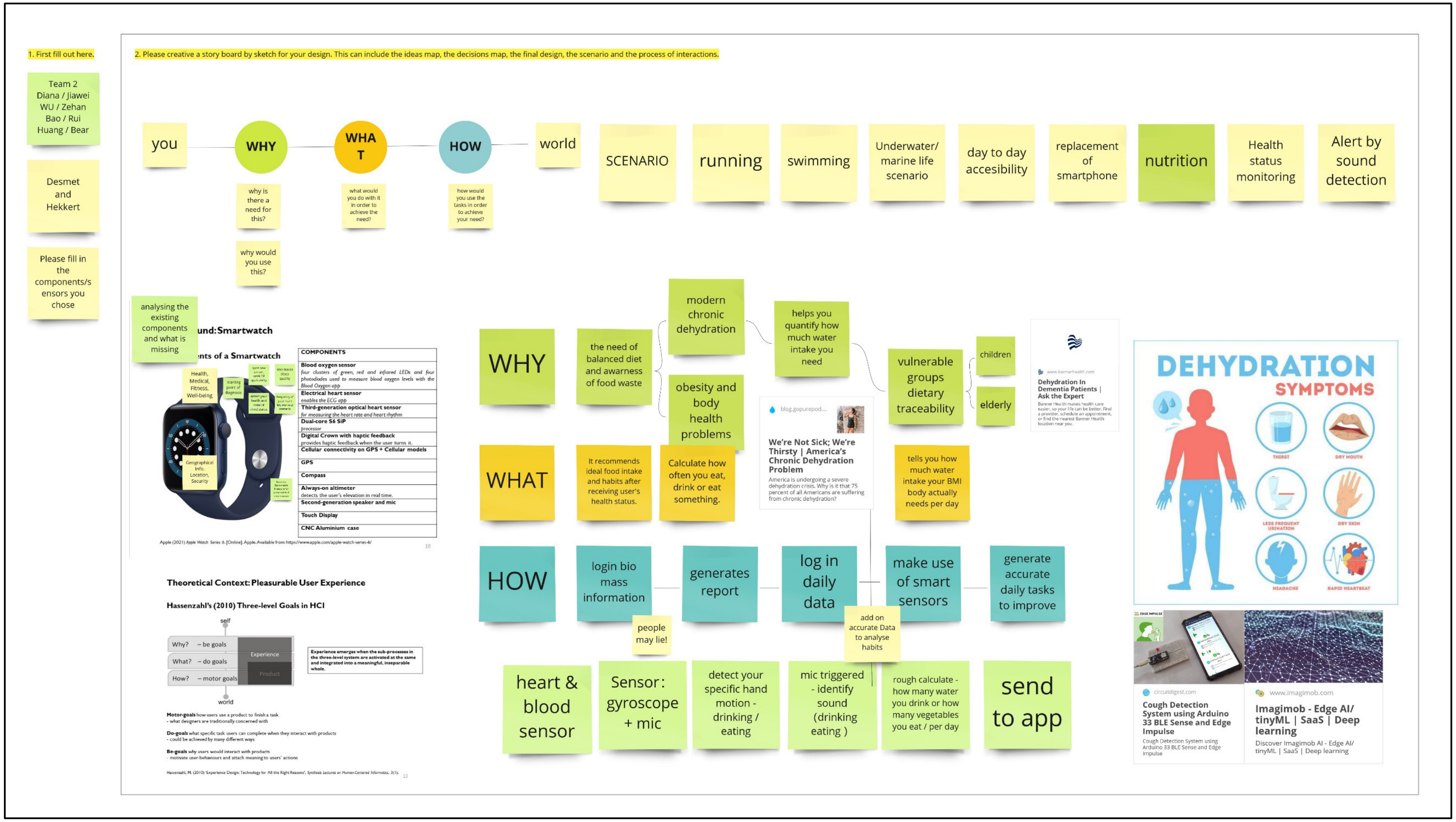



# Appendix G. Workshop 2 Results

## Group 1



## Group 2


1. First fill out here.
Team 2 Diana / Jiawei WU / Zehan Bao / Rui Huang / Bear
Desmet and Hekkert
Please fill in the components/sensors you chose
2. Please creative a story board by sketch for your design. This can include the ideas map, the decisions map, the final design, the scenario and the process of interactions.
you
WHY
WHAT
HOW
world
why is there a need for this?
what would you do with it in order to achieve the need?
how would you use the tasks in order to achieve your need?
why would you use this?
SCENARIO
running
swimming
Underwater/ marine life scenario
day to day accesibility
replacement of smartphone
nutrition
Health status monitoring
Alert by sound detection
analysing the existing components and what is missing
WHY
the need of balanced diet and awareness of food waste
modern chronic dehydration
obesity and body health problems
helps you quantify how much water intake you need
vulnerable groups dietary traceability
children
elderly
We're Not Sick; We're Thirsty | America's Chronic Dehydration Problem
Dehydration In Dementia Patients | Ask the Expert
WHAT
It recommends ideal food intake and habits after receiving user's health status.
Calculate how often you eat, drink or eat something.
tells you how much water intake your BMI body actually needs per day
DEHYDRATION SYMPTOMS
HOW
login bio mass information
people may lie!
generates report
log in daily data
add on accurate Data to analyse habits
make use of smart sensors
generate accurate daily tasks to improve
heart & blood sensor
Sensor: gyroscope + mic
detect your specific hand motion - drinking / eating
mic triggered - identify sound (drinking eating )
rough calculate - how many water you drink or how many vegetables you eat / per day
send to app
Cough Detection System using Arduino 33 BLE Sense and Edge Impulse
Imagimob - Edge AI/ tinyML | SaaS | Deep learning
Theoretical Context: Pleasurable User Experience
Hassenzahl's (2010) Three-level Goals in HCI

# Group 3

1. First fill out here.

Debra, Linda, Emre, Miyuki, Yves

Hassenzahl's Three-level-goals

opical heart sensor, GPS, Touch Display

2. Please creative a story board by sketch for your design. This can include the ideas map, the decisions map, the final design, the scenario and the process of interactions.

**Background: Smartwatch**

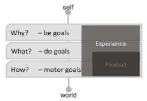
**Components of a Smartwatch**

| COMPONENTS |
|---|
| **Blood oxygen sensor** *four clusters of green, red and infrared LEDs and four photodiodes used to measure blood oxygen levels with the Blood Oxygen app* |
| **Electrical heart sensor** *enables the ECG app* |
| **Third-generation optical heart sensor** *for measuring the heart rate and heart rhythm* |
| **Dual-core S6 SiP** *processor* |
| **Digital Crown with haptic feedback** provides haptic feedback when the user turns it. |
| **Cellular connectivity on GPS + Cellular models** |
| **GPS** |
| **Compass** |
| **Always-on altimeter** detects the user's elevation in real time. |
| **Second-generation speaker and mic** |
| **Touch Display** |
| **CNC Aluminium case** |

Apple (2021) Apple Watch Series 6. [Online]. Apple. Available from: https://www.apple.com/apple-watch-series-6/ 18

**Theoretical Context: Pleasurable User Experience**

**Hassenzahl's (2010) Three-level Goals in HCI**




**Experience emerges when the sub-processes in the three-level system are activated at the same and integrated into a meaningful, inseparable whole.**

**Motor-goals** how users use a product to finish a task
- what designers are traditionally concerned with

**Do-goals** what specific task users can complete when they interact with products
- could be achieved by many different ways

**Be-goals** why users would interact with products
- motivate user-behaviours and attach meaning to users' actions

Hassenzahl, M. (2010) 'Experience Design: Technology for All the Right Reasons', Synthesis Lectures on Human-Centered Informatics, 3(1). 13

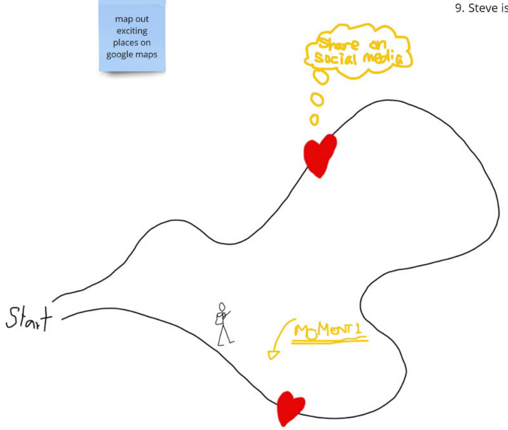
| Hiking | Sensors: Goals: | Optical heart sensor | GPS | Touch display | Cortisol Sensor |
|---|---|---|---|---|---|
| | What - Do Goals | health reason - to see heart rate difference / counting calories | Location and tool tracking | To interact with the device/ choose function | Learn |
| | How - Motor Goals | Overall heart health understanding and reassurance | Find the location/ stay on the right track | To feel safer (check the connection with the internet) | |
| | Why - Be Goals | Be a fitter/ more aware of health progression / sense of achievement / quantified self | Share hike/route on social media<br>Making sure to have some connection / sense of security<br>map out exciting places on google maps | Easier/ More interactive (intuitive) experience compared to buttons. | |

Scenario 1 - memorable moment

1. Steve puts on his watch and gets ready for a hike
2. Steve goes on his hike
3. Steve's heart rate increases as he approaches a beautiful landscape
4. Optical heart sensor records this spike in heart rate
5. Cortisol sensor : confirms it is not a threatening situation
6. GPS records the location
7. Touch display asks if this location wants to be added to memorable moments
8. Steve confirmes
9. Touch display confirms

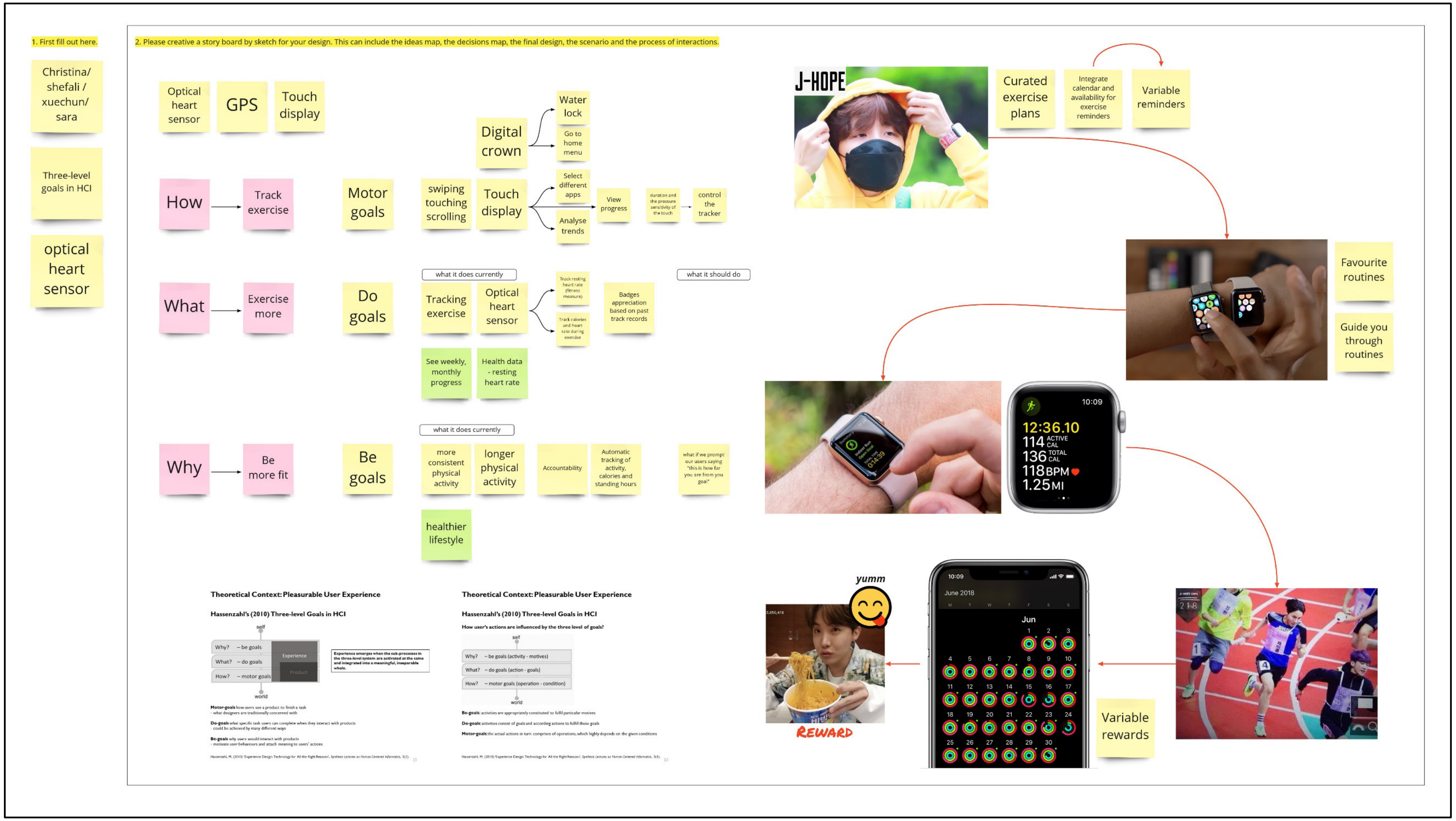
Scenario 2 - emergency

1. Steve puts on his watch and gets ready for a hike
2. Steve goes on his hike
3. Steve disappears
4. Steve's heart rate and
5. cortisol levels increase
6. No feedback is is given through the touch display
7. GPS tracks location
8. An emergency call is activated
9. Steve is safe , don't worry :)




| What it was | What it would | |
|---|---|---|
| To quantify and track your calories and fitness progeression | track cortisol levels to ensure elevated heart rate is not as a result of fear/stress | map out, keep track of exciting places (memories) you have visited |
| | Social interactions: help you to share the route | |
| | safety: calls emergency when stress + excitement is detected and no feedback is given through the touch display | |

## Group 4



1. First fill out here.
Christina/ shefali / xuechun/ sara
Three-level goals in HCI
optical heart sensor
2. Please creative a story board by sketch for your design. This can include the ideas map, the decisions map, the final design, the scenario and the process of interactions.
Optical heart sensor
GPS
Touch display
Digital crown
Water lock
Go to home menu
How
Track exercise
Motor goals
swiping touching scrolling
Touch display
Select different apps
Analyse trends
View progress
control the tracker
what it does currently
what it should do
What
Exercise more
Do goals
Tracking exercise
Optical heart sensor
Badges appreciation based on past track records
See weekly, monthly progress
Health data - resting heart rate
what it does currently
Why
Be more fit
Be goals
more consistent physical activity
longer physical activity
Accountability
Automatic tracking of activity, calories and standing hours
healthier lifestyle
Theoretical Context: Pleasurable User Experience
Hassenzahl's (2010) Three-level Goals in HCI
J-HOPE
Curated exercise plans
Integrate calendar and availability for exercise reminders
Variable reminders
Favourite routines
Guide you through routines
12:36.10
114 ACTIVE CAL
136 TOTAL CAL
118 BPM
1.25 MI
yumm
REWARD
June 2018
Jun
Variable rewards

## Group 5

1. First fill out here.

rob, max, kay

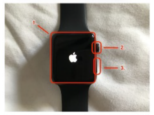
jordan's hierarchy of consumer needs

Altimeter, Blood, Oxygen sensor, GPS, Heart Sensor, Display, Physical Button, Haptic Feedback

2. Please creative a story board by sketch for your design. This can include the ideas map, the decisions map, the final design, the scenario and the process of interactions.

**Jordan's (2003) Hierarchy of Consumer Needs**


### Usability



- show important information
- information hierarchy should be clear, but fine details should not be too hidden

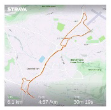
Fine finger movements are limited. clicking on button is okay? (double click for info, triple click for map, etc.)

### Climbing and Diving

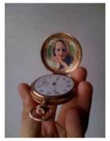
### Functionality

Mini Map for real life for extreme conditions. (hiking, diving, etc) (Who needs your help? Who is behind? Who is dying?)

### Pleasure



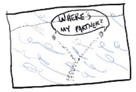
Info graph generated after the climb/ dive to show off to your friends.



display photos of loved one if you are dying. send last letter to loved one so you can camfortably die without worries.


1.Hank is on a south pole expedition with Amy.

- polar expedition
- hank and amy are excited for their expedition
- blizzard rolls in, they can't see each other
- hank screams but amy cannot hear because of the blizzard
- watch alerts amy that hank heart rate is elevated
- amy wants to find hank
- watch tells amy which direction hank is in
- amy finds and rescues hank
- thanks watch!




2. A blizzard happens, people cannot see anything.


3. Haptic feedback sends morse code SOS to Amy. Amy checks the watch and sees Hank is far away from the center of the group and HIS heart rate is very elevated


4.Amy need to decide if she need to leave HANK behind or go help HIM.

5.Hank need to be left behind, a picture of hank's family is displayed on HIS watch as HE dies. A message is sent to Amy telling him it was a good expedition and keep going.


5.Amy go save Hank and they use the watch to find each other in the storm.

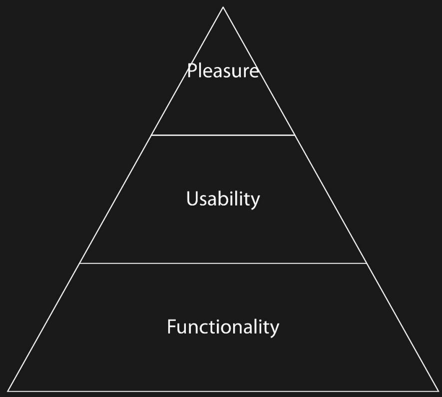
# Appendix H. Workshop 3 Presentation Slides


**Hierarchy of Consumer Needs (Jordan, 2003)**

**Functionality** "a product will be useless if it does not contain appropriate functionality, a product cannot be usable if it does not contain the functions necessary to perform the tasks for which it is needed".

**Usability** "once people had become used to having appropriate functionality then wanted products that were easy to use".

**Pleasure** "having become used to usable products, it seems inevitable that people will soon want something more: […] products that bring not only functional benefits but also emotional ones




Jordan, P. (2003). Designing pleasurable products : An introduction to the new human factors. London: Taylor & Francis e-Library.

**Definitions of Internet of Things**

British technology-pioneer Kevin Ashton first coined the term in 1999 to describe, "a system in which objects in the physical world could be connected to the Internet by sensors"

Nowadays, the term, "IoT" is used to describe, "scenarios in which Internet connectivity and computing capability extend to a variety of objects, devices, sensors, and everyday items" (International Telecommunications Union, 2016: 10).

International Telecommunications Union (2016). *Harnessing the Internet of Things for Global Development.*

**SPIME**

“SPIMES are manufactured objects whose informational support is so overwhelmingly extensive and rich that they are regarded as material instantiations of an immaterial system. People within an infrastructure of SPIMES are Wranglers (Sterling, 2005, 11).”

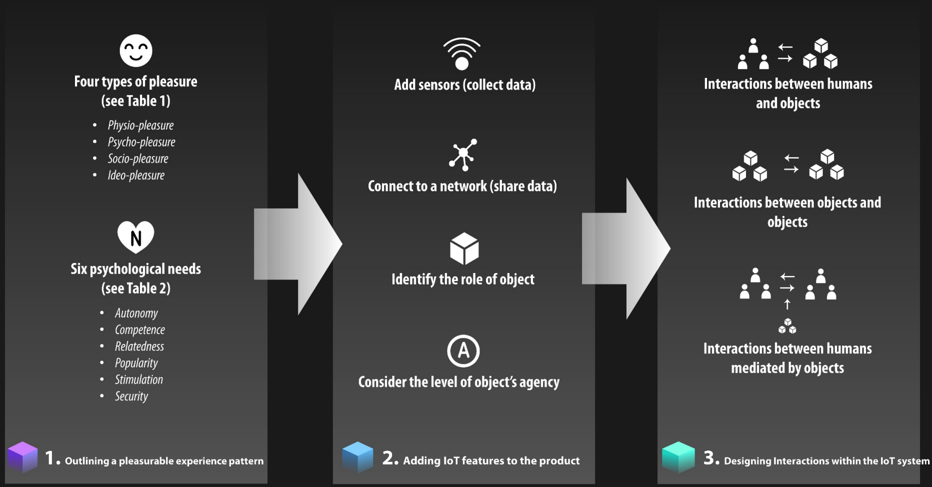
Sterling, B. (2005). Shaping things. Cambridge, Mass. ; London: MIT Press.

## How do we design pleasurable experiences by transforming analogue products into IoT products?

## Design Experience From an Experience Pattern

"(Experience design) It starts with an individual experience of feeling close to significant others and the suggestion to distill the essence of such a positive and meaningful experience into a pattern. The pattern allows to transfer the experience into a new context, and to design a novel experience based on the knowledge about a happy moment captured by the pattern." (Hassenzahl *et al.*, 2013)

Hassenzahl, M., Eckoldt, K., Diefenbach, S., Laschke, M., Lenz, E., & Kim, J. (2013). Designing moments of meaning and pleasure. Experience design and happiness. *International Journal of Design*, ***7***(3), 21-31.




**The IoT Transformation for Pleasurable Experiences (IoTT for PLEX) Framework**

**Four types of pleasure**

- *Physio-pleasure*
- *Psycho-pleasure*
- *Socio-pleasure*
- *Ideo-pleasure*

**Six phycological needs**

- *Autonomy*
- *Competence*
- *Relatedness*
- *Popularity*
- *Stimulation*
- *Security*

1. Outlining a pleasurable experience pattern

| | |
|---|---|
| **Physio-pleasure** | Relates to the body and pleasures derived from the sensory organs. They include pleasures connected with touch, taste and smell, as well as feelings of sensual pleasure. |
| **Socio-pleasure** | Enjoyment derived from relationships with others, e.g., relationships with friends and loved ones, with colleagues or with like-minded people. |
| **Psycho-pleasure** | Psycho-pleasure pertains to people's cognitive and emotional reactions. |
| **Ideo-pleasure** | Ideo-pleasure pertains to people's values. |

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1. Outlining a pleasurable experience pattern

| | |
|---|---|
| **Autonomy** | Feeling that you are the cause of your own actions rather than feeling that external forces or pressure are the cause of your action. |
| **Competence** | Feeling that you are very capable and effective in your actions rather than feeling incompetent or ineffective. |
| **Relatedness** | Feeling that you have regular intimate contact with people who care about you rather than feeling lonely and uncared for. |
| **Popularity** | Feeling that you are liked, respected, and have influence over others rather than feeling like a person whose advice or opinion nobody is interested in. |
| **Stimulation** | Feeling that you get plenty of enjoyment and pleasure rather than feeling bored and under-stimulated by life. |
| **Security** | Feeling safe and in control of your life rather than feeling uncertain and threatened by your circumstances. |

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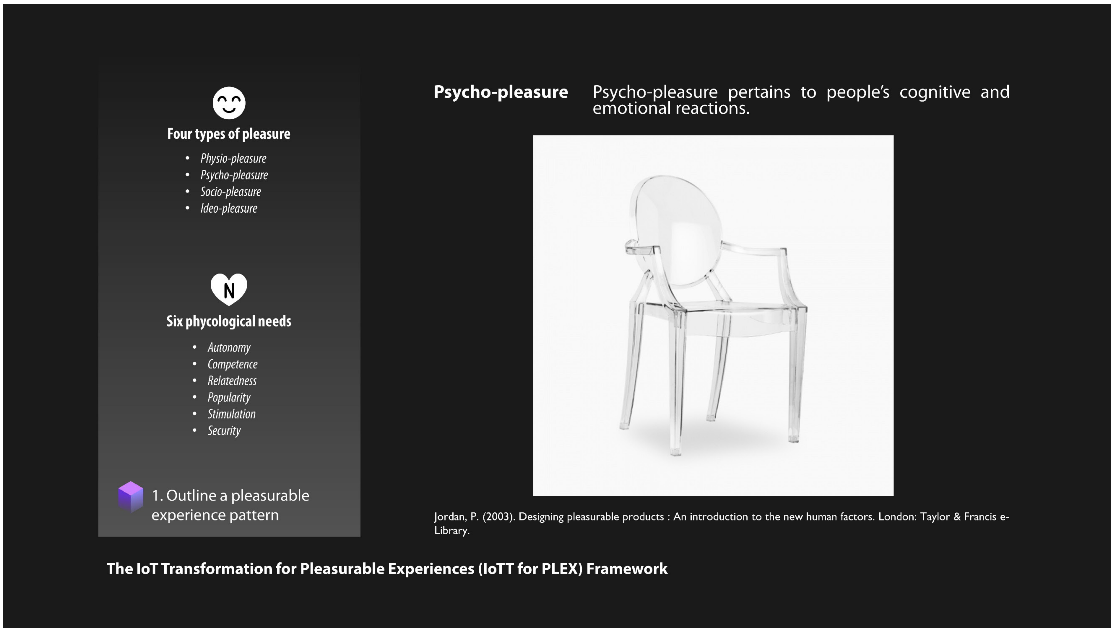
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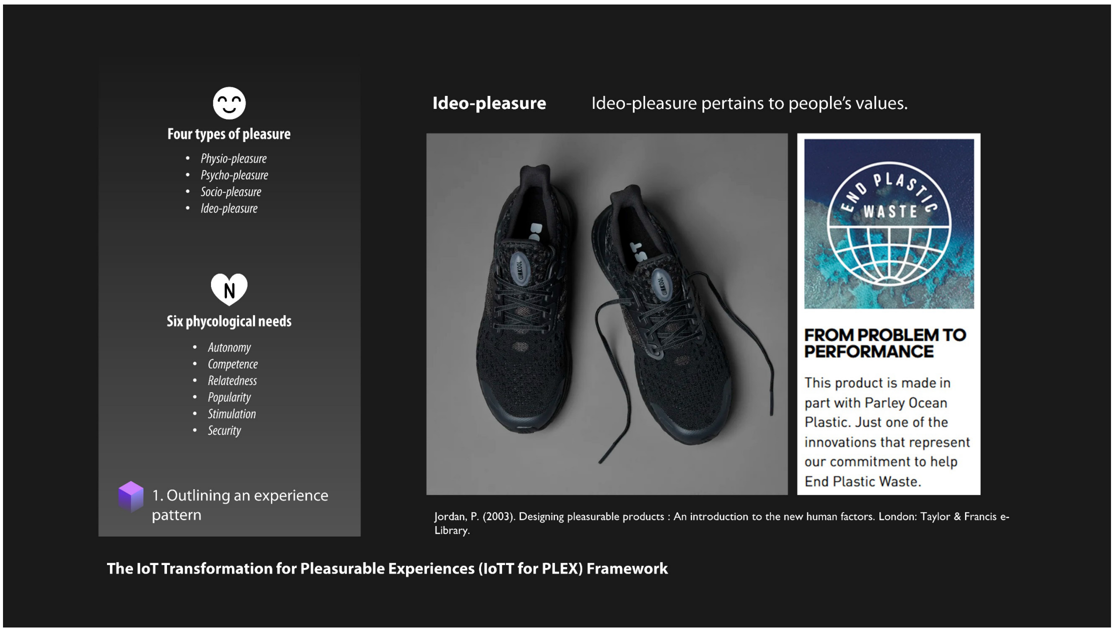
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END PLASTIC WASTE
FROM PROBLEM TO PERFORMANCE
This product is made in part with Parley Ocean Plastic. Just one of the innovations that represent our commitment to help End Plastic Waste.
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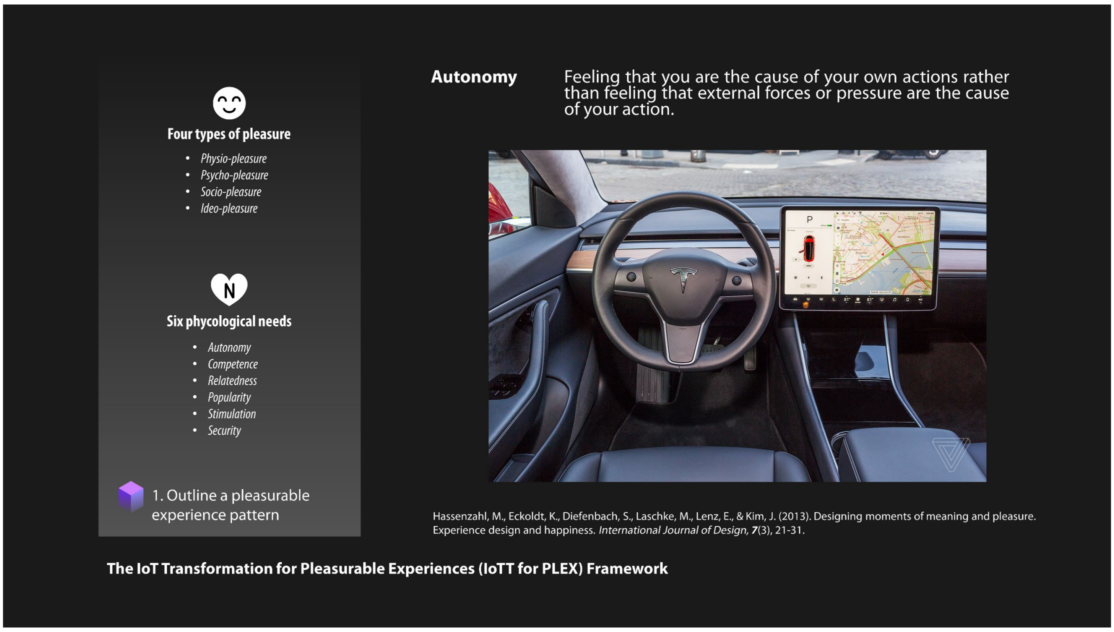
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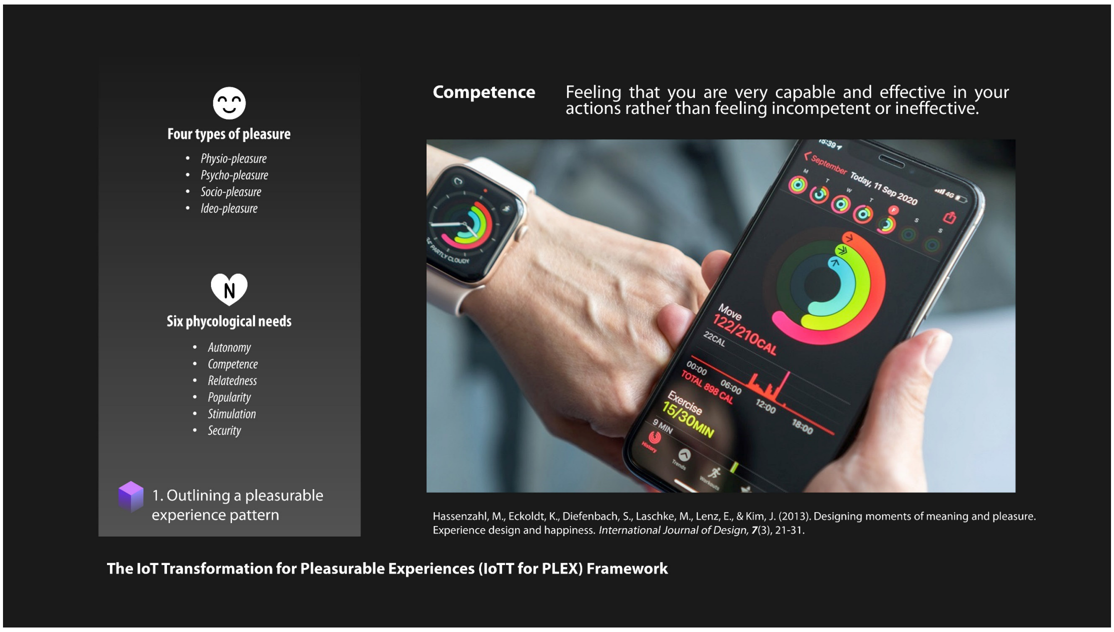
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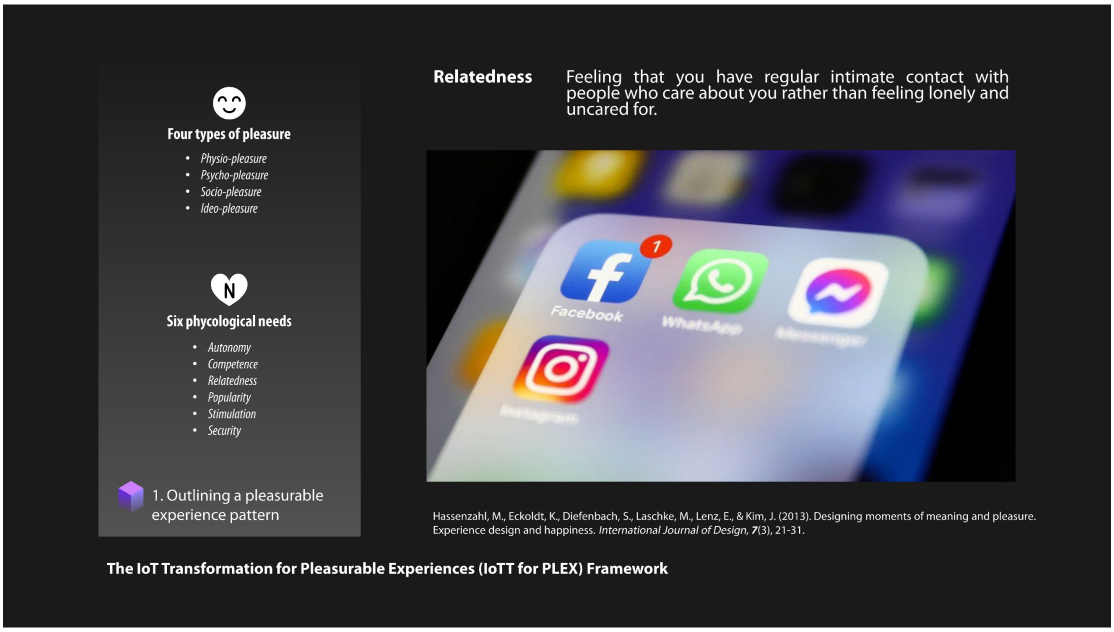
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Facebook
WhatsApp
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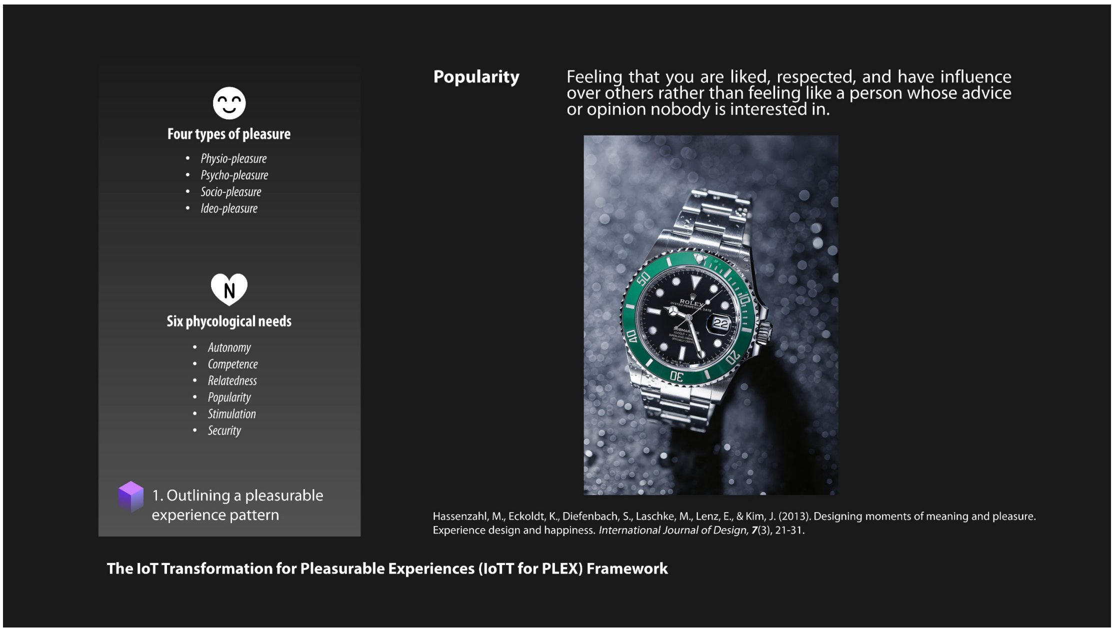
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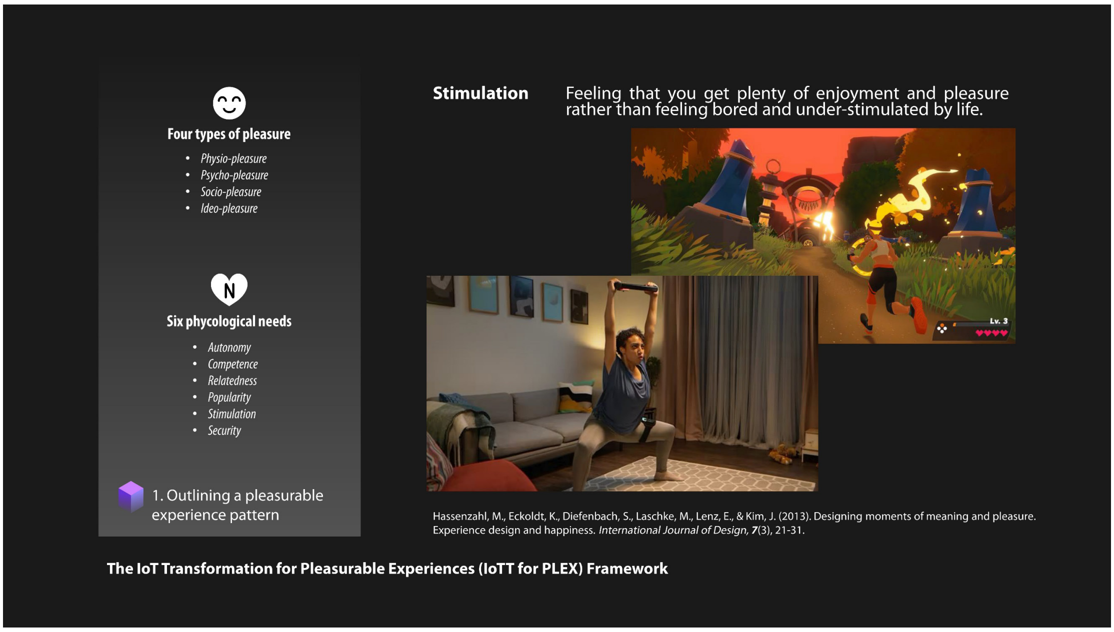
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Feeling that you get plenty of enjoyment and pleasure rather than feeling bored and under-stimulated by life.
Lv. 3
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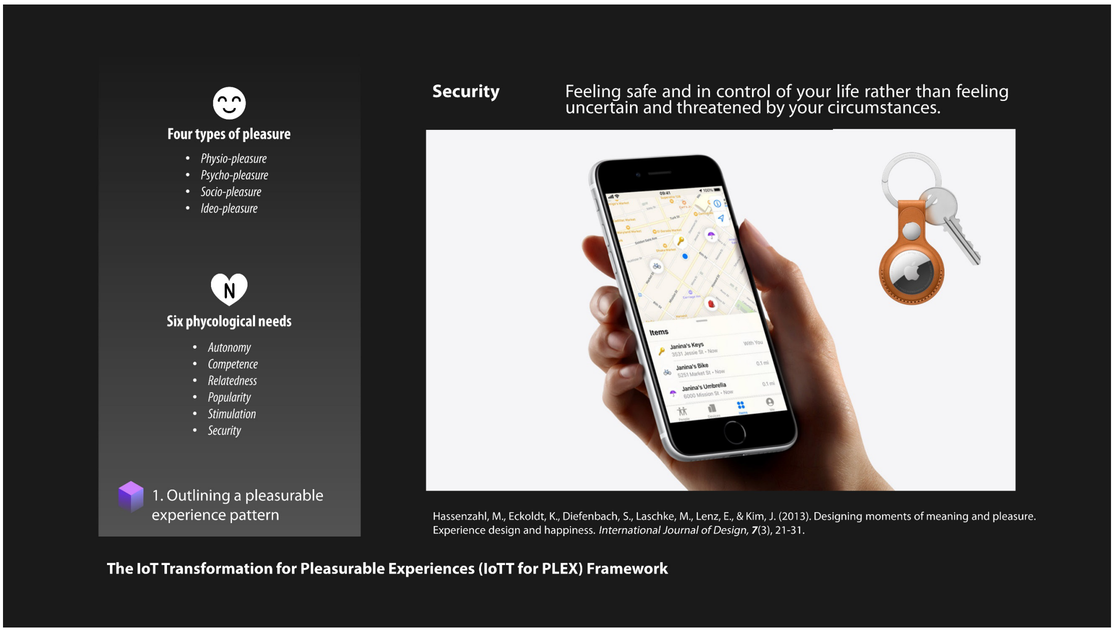
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Security
Feeling safe and in control of your life rather than feeling uncertain and threatened by your circumstances.
Items
Janina's Keys
Janina's Bike
Janina's Umbrella
Hassenzahl, M., Eckoldt, K., Diefenbach, S., Laschke, M., Lenz, E., & Kim, J. (2013). Designing moments of meaning and pleasure. Experience design and happiness. International Journal of Design, 7(3), 21-31.
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- *Security*

1. Outlining a pleasurable experience pattern

"Need fulfilment was clearly linked to hedonic quality perceptions, but not as strongly to pragmatic quality (i.e., perceived usability), which supports the notion of hedonic quality as 'motivator' and pragmatic quality as 'hygiene factor (Hassenzahl, Diefenbach & Göritz, 2010)."

"Hedonic quality refers to quality dimensions with no obvious—or at least a second order relation to task-related goals such as originality, innovativeness, and so forth (Hassenzahl, 2001). "

Hassenzahl, M., Diefenbach, S. & Göritz, A. (2010) Needs, affect, and interactive products - Facets of user experience. Interacting with Computers. 22 (5), 353–362. doi:10.1016/j.intcom.2010.04.002.

**The IoT Transformation for Pleasurable Experiences (IoTT for PLEX) Framework**

**Add sensors (collect data)**

**Connect to a network (share data)**

**Identify the role of object**

**Consider the level of object's agency**

2. Adding IoT features to the product

**Sensors:**

accelerometer, gyroscope sensor, blood-oxygen sensor, humidity sensor, thermometer, ultrasonics sensor, light proximity, infrared sensor (IR sensor), collision sensor, sound sensor, GPS sensor, Compass, electrical heart sensor, optical heart sensor and more…

**Network:**

Who are connected in the network? Are they humans or other objects?

What type of data are they sharing?

What is the meaning of sharing these data?

**The IoT Transformation for Pleasurable Experiences (IoTT for PLEX) Framework**

Add sensors (collect data)

Connect to a network (share data)

Identify the role of object

Consider the level of object's agency

2. Adding IoT features to the product

| *Role* | *Agency* |
|---|---|
| **The Collector** | Low |
| **the Actor** | Medium |
| **the Creator** | High |

Cila, N., Smit, I., Giaccardi, E. & Kröse, B. (2017) Products as Agents: Metaphors for Designing the Products of the IoT Age. In: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems.* New York, NY, USA, Association for Computing Machinery. pp. 448–459.

**The IoT Transformation for Pleasurable Experiences (IoTT for PLEX) Framework**

Add sensors (collect data)

Connect to a network (share data)

Identify the role of object

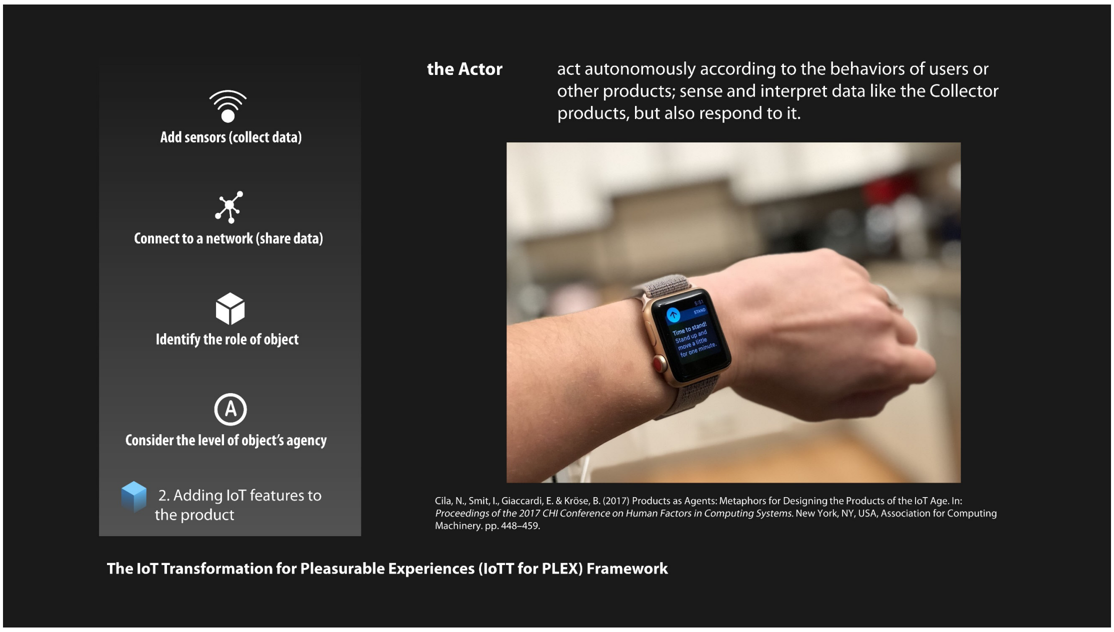
Consider the level of object's agency

2. Adding IoT features to the product

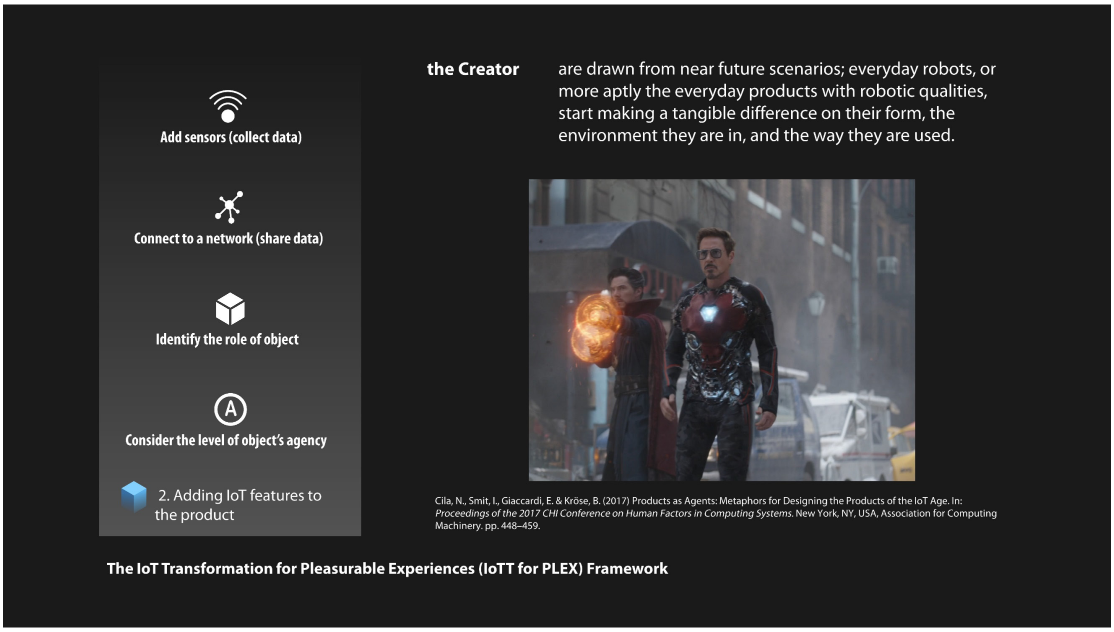
**The Collector** sense and process information; have the ability to aggregate data from embedded sensors or social media platforms and feed the data back to its user, to other users, or to other products.

Cila, N., Smit, I., Giaccardi, E. & Kröse, B. (2017) Products as Agents: Metaphors for Designing the Products of the IoT Age. In: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems.* New York, NY, USA, Association for Computing Machinery. pp. 448–459.

**The IoT Transformation for Pleasurable Experiences (IoTT for PLEX) Framework**



Add sensors (collect data)
Connect to a network (share data)
Identify the role of object
Consider the level of object's agency
2. Adding IoT features to the product
the Actor
act autonomously according to the behaviors of users or other products; sense and interpret data like the Collector products, but also respond to it.
Cila, N., Smit, I., Giaccardi, E. & Kröse, B. (2017) Products as Agents: Metaphors for Designing the Products of the IoT Age. In: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems. New York, NY, USA, Association for Computing Machinery. pp. 448–459.
The IoT Transformation for Pleasurable Experiences (IoTT for PLEX) Framework

Add sensors (collect data)
Connect to a network (share data)
Identify the role of object
Consider the level of object's agency
2. Adding IoT features to the product
the Creator
are drawn from near future scenarios; everyday robots, or more aptly the everyday products with robotic qualities, start making a tangible difference on their form, the environment they are in, and the way they are used.
Cila, N., Smit, I., Giaccardi, E. & Kröse, B. (2017) Products as Agents: Metaphors for Designing the Products of the IoT Age. In: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems. New York, NY, USA, Association for Computing Machinery. pp. 448–459.
The IoT Transformation for Pleasurable Experiences (IoTT for PLEX) Framework

Interactions between humans and objects

Interactions between objects and objects

Interactions between humans mediated by objects

3. Designing Interactions within the IoT system

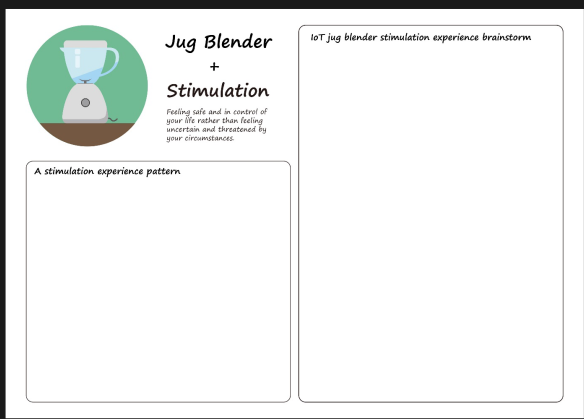
| IN/OUT | Single Object (in) | Single Human (in) | Multiple Objects (in) | Multiple Humans (in) |
|---|---|---|---|---|
| Single Object (out) | Object-to-object interactions | Human-to-object interactions | Objects-to-object interactions | Humans-to-object interactions |
| Single Human (out) | Object-to-human interactions | Human-to-human interactions | Objects-to-human interactions | Humans-to-human interactions |
| Multiple Objects (out) | Object-to-objects interactions | Human-to-objects interactions | Objects-to-objects interactions | Humans-to-objects interactions |
| Multiple Humans (out) | Object-to-humans interactions | Human-to-humans interactions | Objects-to-humans interactions | Humans-to-human interactions |

Interactions between humans and objects | Interactions between objects | Interactions between humans mediated by objects

**The IoT Transformation for Pleasurable Experiences (IoTT for PLEX) Framework**

**Task 1. Ideation: from pattern to experience (40mins)**

1. Select a task card
2. Outline an experience pattern for the type of pleasure/ psychological need shown on the task card
3. Brainstorm experience ideas that elicits the type of pleasure/ fulfil the psychological needs by transferring the traditional product into an IoT product based on your outlined pattern
4. When you brainstorm, think about the sensors you are going to use, the data the IoT product collecting and sharing, the role of the IoT object in the network



**An example of relatedness experience pattern**

Ben had to move from London to New York for his new job. When he was living in New York, he had a video call with his wife everyday. They usually talked about their daily activities and if they carried out the same activity in a day (e.g. doing yoga, jogging), they would have a more interesting and longer chat. Ben felt that he had really intimate contact with his loved one who cared about him in these video calls.

**An example of an IoT product (smartwatch) relatedness experience**

Ben had to relocate from London to New York for his new job. Before he left, both he and his wife purchased smartwatches. Using the 'health' app on their smartwatches, they could compare the number of steps walked and calories consumed daily with each other. Comparing exercise data became a daily activity for the couple and a starting point for dialogue during their video calls. When they checked their dashboards and compared their health data, they felt a strong sense of care for each other and a deep connection.

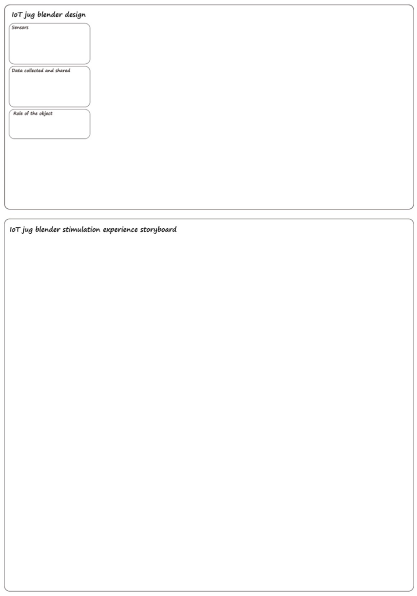
**Get your group number.**

**Work in your group (40 mins).**

## Presentation and Discussion (3 mins for each group)

**Task 2. Design: from experience patterns to experience design**
**(1 hour)**

1. Decide the sensors you chose, the data your product collecting and share, the role of the IoT product in your final idea.
2. Visually present your final idea and its detail.
3. After finishing the product design, create a storyboard present how user gain the pleasure or fulfils the psychological needs through the interactions in the IoT system.



Presentation and Discussion (5 mins for each group)

# Appendix I. Workshop 3 Consent Form

Royal College of Art

RESEARCH& INNOVATION

**Participant Project Information & Consent Form***

(One signed copy of this form should be retained by the Participant and one copy by the Project Researcher)

*Design Workshop*

*Designing Pleasurable Experience by Transforming Analogue Products into IoT Forms*

For further information
Supervisor: Dr Bjorn Sommer
*ethics@rca.ac.uk*

*28/05/2022*

Dear Potential Participant,

*I am Zidong Lin a PhD candidate* in Design Research at the Royal College of Art. As part of my PhD studies, *I am* conducting a design workshop entitled *Designing Pleasurable Experience by Transforming Analogue Products into IoT Forms*. You are invited to take part in this research project which explores how to design pleasurable experiences by transferring non-IoT products into IoT forms.

If you consent to participate, this will involve:

- **A presentation** introduces the context of IoT, experience design theories and a design framework developed by workshop organisers.
- **Creative Task 1:** Adding IoT features on an analogueproduct and design a pleasurable experience from an experience pattern.

**Research Office** Royal College of Art Kensington Gore London SW7 2EU
t +44 (0)20 7590 4126 f +44 (0)20 7590 4542 research@rca.ac.uk www.rca.ac.uk/research

- **Creative Task 2:** Design the details of your IoT product and present the pleasurable experience scenario.

As the part of presentation has not been published by the researchers yet, please do **NOT** take photos of the slides and take away any printed material used in the workshop.

We will take some photos to record the process of the workshop. Some scenes might be shown in future published academic papers but in these photos your face will be blurred. The concepts you developed in the workshop might also be presented in the future paper and they might be selected and further developed in my future research. To participate in the workshop, you need to understand and agree that your concepts developed in the workshop remains the property of the researchers (Jerry Zidong Lin and Bjorn Sommer) and you waive all rights to them.

Participation is entirely voluntary. You can withdraw at any time up to the point of publication and there will be no disadvantage if you decide not to complete the study. All information collected will be confidential. All information gathered will be stored securely and once the information has been analysed all individual information will be destroyed.

At no time will any individual be identified in any reports resulting from this study. Images or quotes, which may allow you to be identified will only be used with your express permission.

If you have any concerns or would like to know the outcome of this project, please contact my supervisor (insert supervisor's name) at the above address.

Thank you for your interest.

I *(please print)* ……………………………….. have read the information above and all queries have been answered to my satisfaction. I agree to voluntarily participate in this research and give my consent freely. I understand that I can withdraw my participation from the project up to the point of publication, without penalty, and do not have to give any reason for withdrawing.

I understand that all information gathered will be stored securely, and my opinions will be accurately represented. Any data in which I can be clearly identified will be used in the public domain only with my consent.

I hereby certify that I am in good health and do not suffer from a heart condition, contagious dermatological condition, or other ailment which could be exacerbated by participation in the VR experience, or pose a risk to other participants.

Participant Signature……………………………………………………………….

Researcher Signature……………………………………………………………….

Date: ………………………………………………………………………

**Complaints Procedure:**

This project follows the guidelines laid out by the Royal College of Art Research Ethics Policy.

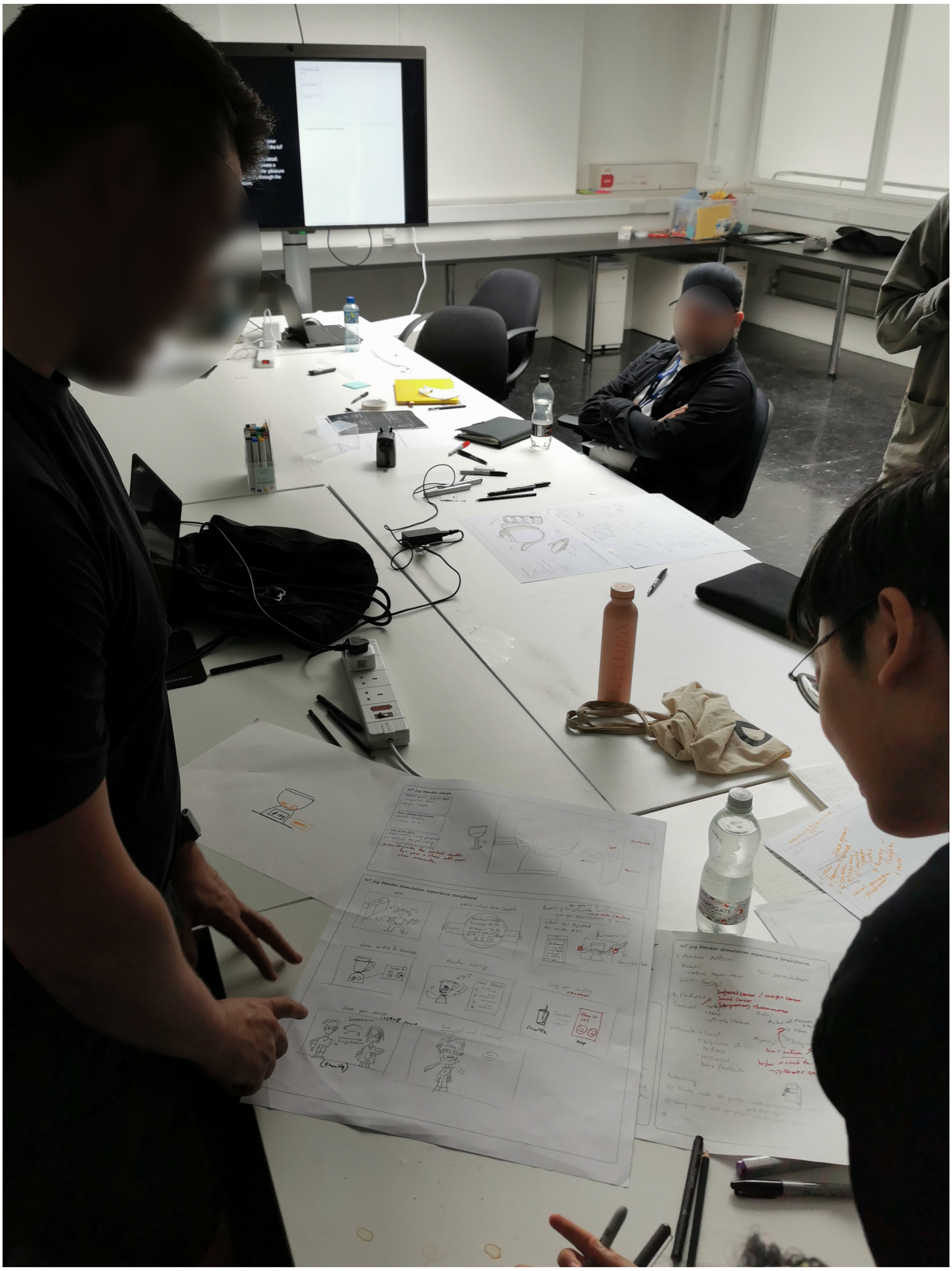
If you have any questions, please speak with the researcher. If you have any concerns or a complaint about the manner in which this research is conducted, please contact the RCA Research Ethics Committee by emailing ethics@rca.ac.uk or by sending a letter addressed to:

The Research Ethics Committee
Royal College of Art
Kensington Gore
London
SW7 2EU

# Appendix J. Workshop 3 Photos

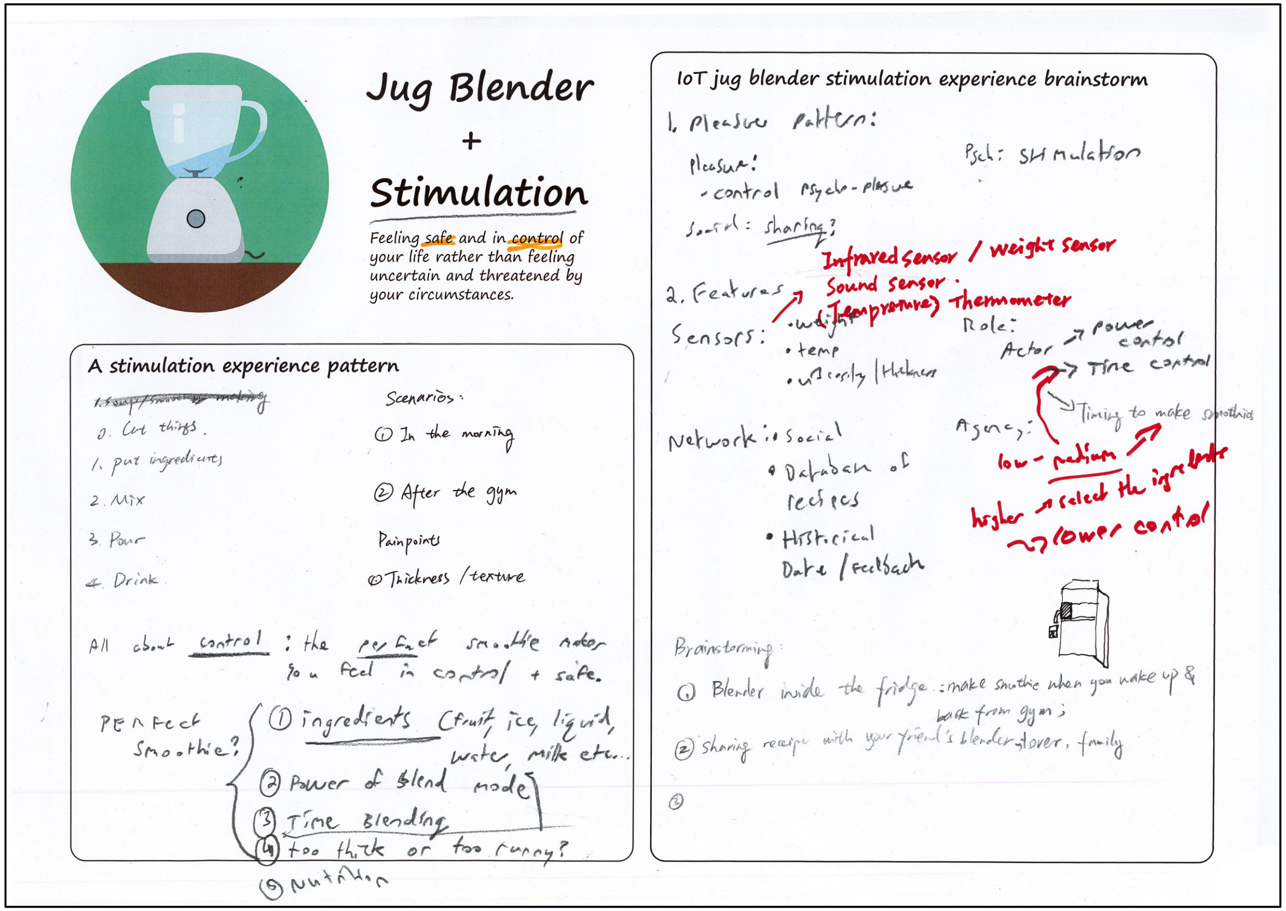


Task 1. Ideation
(40mins)



# Appendix K. Workshop 3 Results

## Group 1



## IoT jug blender design

**Sensors** Input WATCH DATA

Temparetrue Sensor

Weight Sensor

**Data collected and shared**

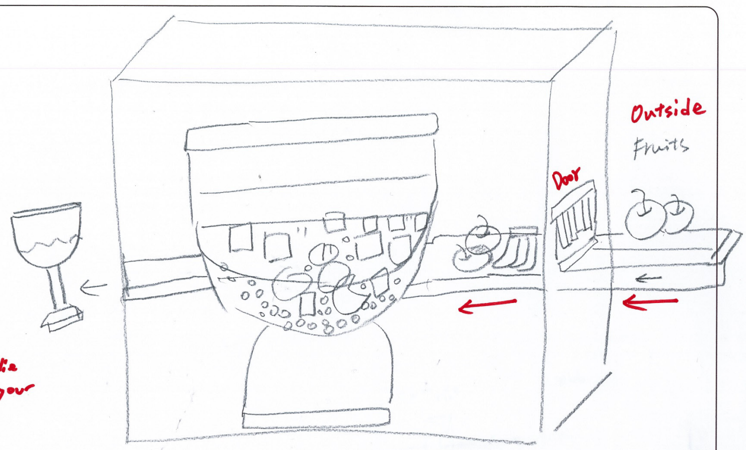
Health data :

Location data

**Role of the object**

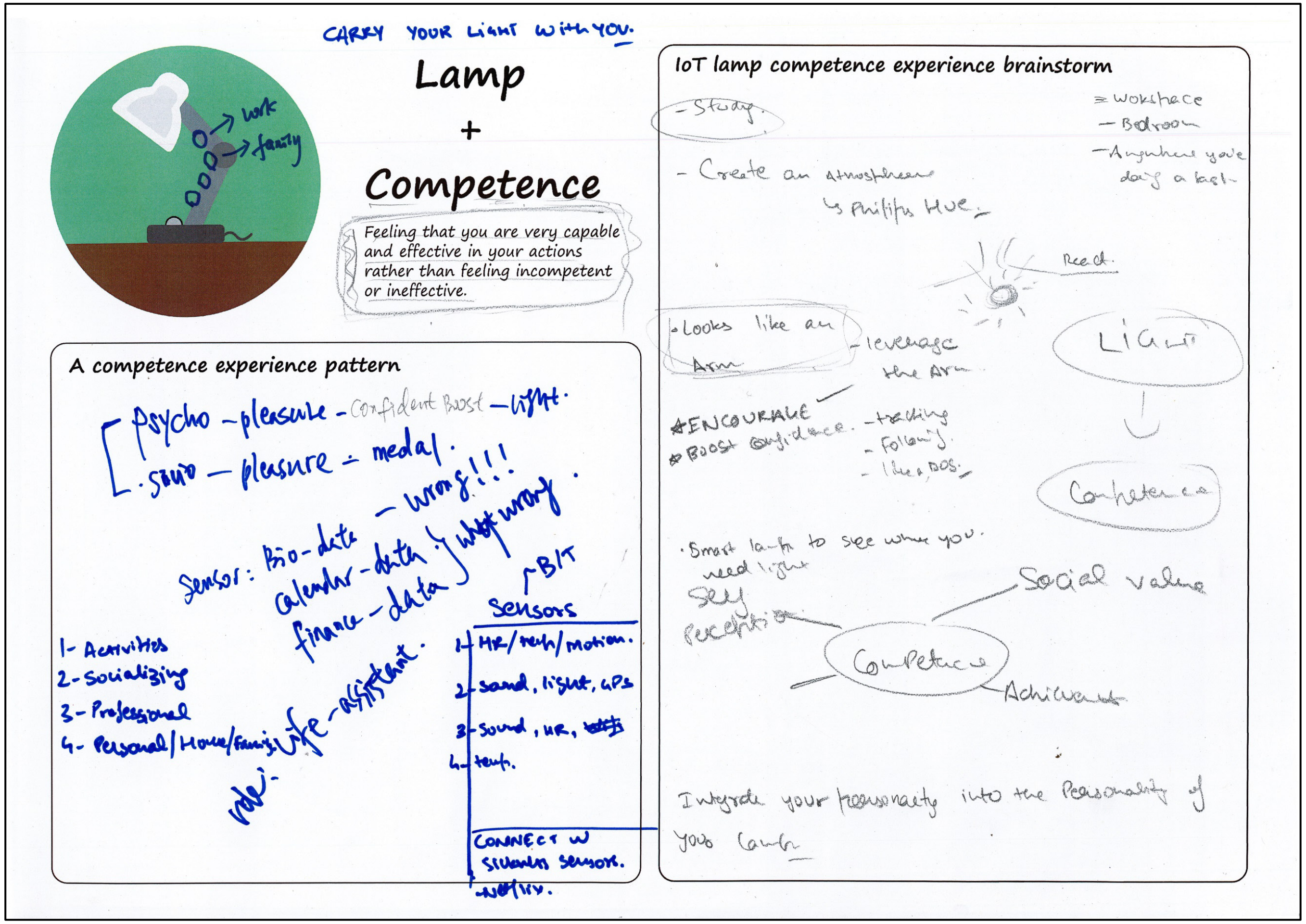
Make smothies contains nutrition you need at the good timing and thickness you like

actor → create the perfect smoothie for you + share with your close community.




## IoT jug blender stimulation experience storyboard

**Group 2**


CARRY YOUR LIGHT WITH YOU.
work
family
Lamp
+
Competence
Feeling that you are very capable and effective in your actions rather than feeling incompetent or ineffective.
A competence experience pattern
psycho - pleasure - confident boost - light.
socio - pleasure - medal.
Sensor: Bio-data - wrong!!!
calendar - data
finance - data
what wrong.
1- Activities
2- Socializing
3- Professional
4- Personal/Home/family
life-assistant.
role.
BIT
Sensors
1- HR/temp/motion.
2- sound, light, GPS
3- sound, HR,
4- temp.
CONNECT W STUDENTS SENSORS.
IoT lamp competence experience brainstorm
- Study.
- workplace
- Bedroom
- Anywhere you're doing a task
- Create an atmosphere
Philips Hue
Read.
Looks like an Arm
leverage the Arm
ENCOURAGE
BOOST confidence.
- tracking
- Following
- likes, DOS.
Light
Competence
Smart lamp to see when you need light.
Self perception
Social value
Competence
Achievement
Integrate your personality into the personality of your lamp

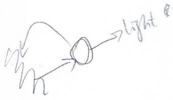
## IoT lamp design

**Sensors** Bio data. (Heart Beat temperature)
sound / light /
GPS / language

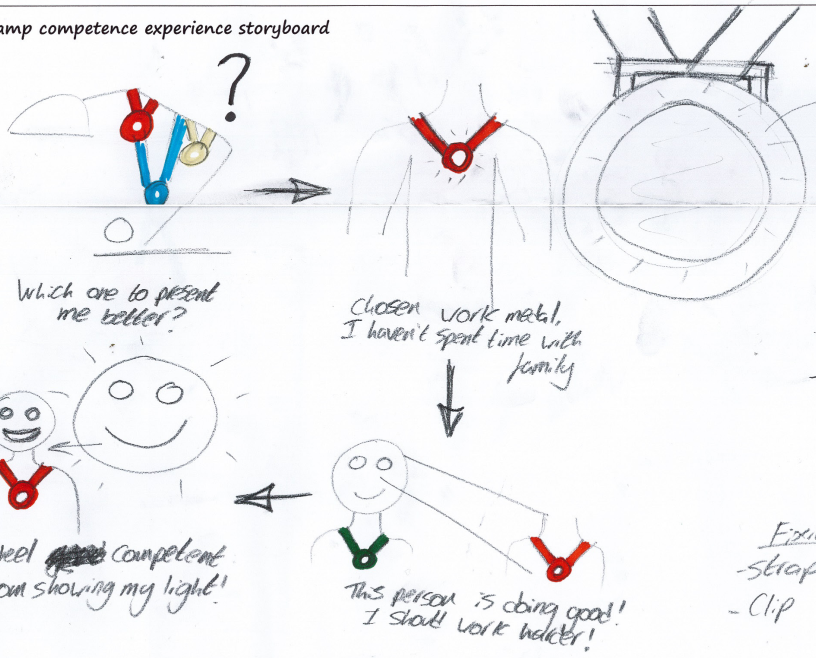
**Data collected and shared** calendar (work). Bio X visualization ✓

**Role of the object**
→ reflect reality.
→ Boost confident.
→ can choose the one you want show off

memory :




## IoT lamp competence experience storyboard




Different materials for activity

Gym fabric
- Soft fabric for family
  ↳ Pin pictures
- Desk material
- Material to resemble personality

Velcro

Fixing
- strap
- Clip

**Group 3**

# Teapot + Relatedness

*Feeling that you have regular intimate contact with people who care about you rather than feeling lonely and uncared for.*

## A relatedness experience pattern

Context:
- Hosting people for tea in a social occasion

| Emotional | Functional |
|---|---|
| - awkward silences | - finish before someone else |
| - different etiquettes (i.e. insisting vs accepting) | - making a new pot |
| - a trick you do (pause of a sip) | - running out of tea |
| - optional conversation | - Spilling the tea |
| | - optional brewing time |
| | - tea gets cold |

gossip?

INDIA

CHAI & CIGS

## IoT teapot relatedness experience brainstorm

~~Function~~

Game around teapots

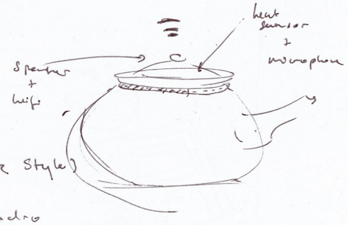
Cups connected to the saucer
- weight sensor

Remotely connected between homes

Slurp tea

other products?
- Zoom

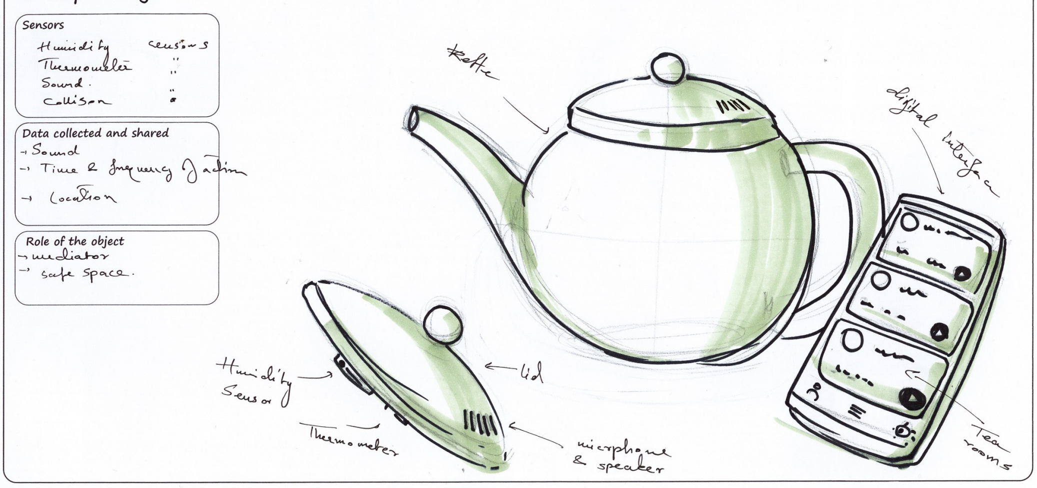
tea pot podcast (ASMR style)
-> Streaming audio
-> noise sensor



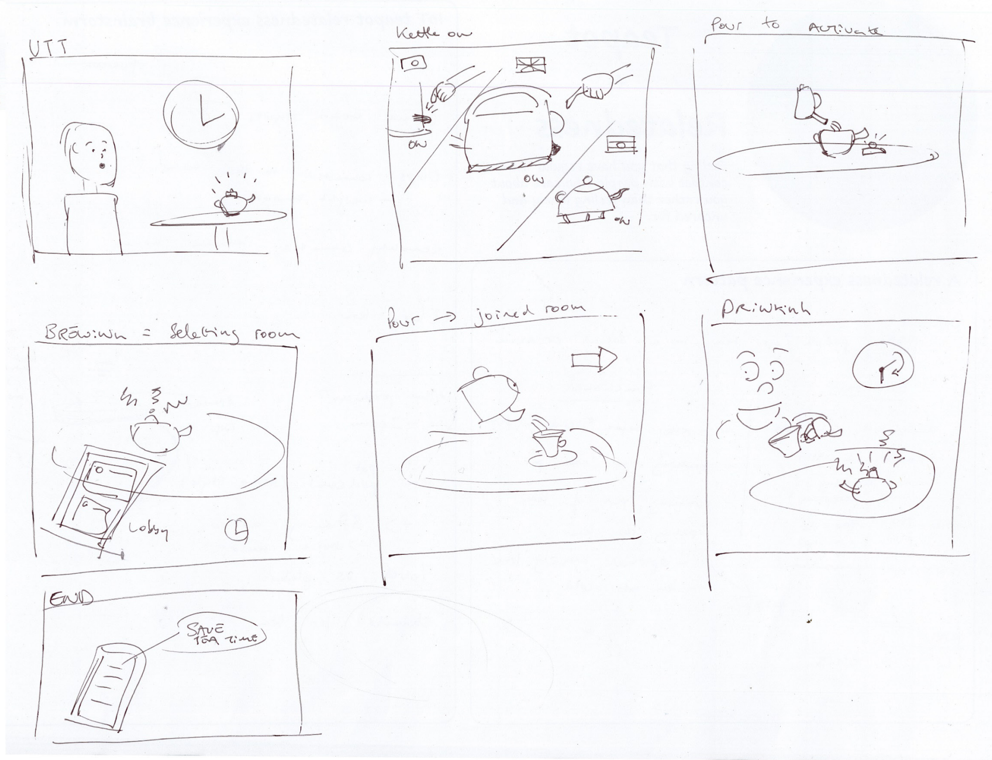

local vs global

channels for tea

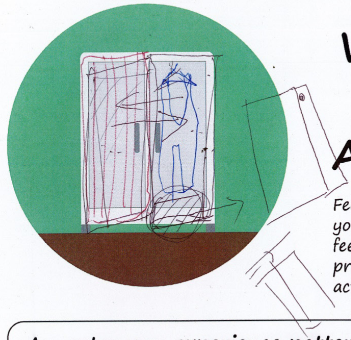
## IoT teapot design




## IoT teapot relatedness experience storyboard



**Group 4**



# Wardrobe + Autonomy

*Feeling that you are the cause of your own actions rather than feeling that external forces or pressure are the cause of your action.*

## An autonomy experience pattern

wardrobe - choosing clothing - fashion vs. utility
- storage
- having too many of the same types of clothing
- vanity

choose outfit in the morning, to fit weather, occasion, comfort, etc.

capsule wardrobe - sorted in seasons, styles, etc.

Giving the user the choice of autonomy or automation.

Smart mirror

## IoT wardrobe autonomy experience brainstorm

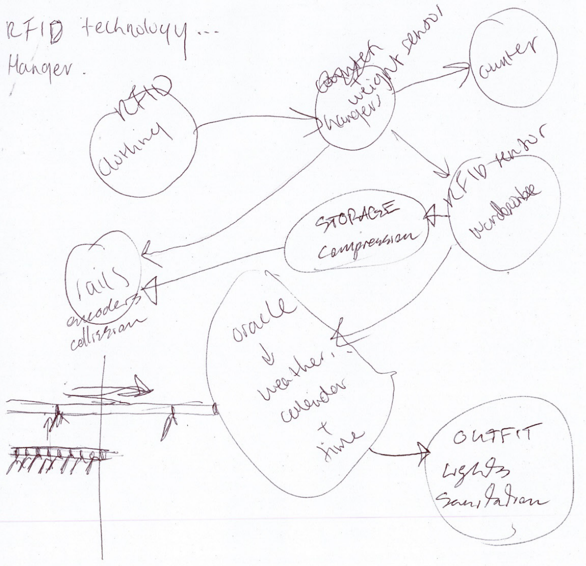
Counter for laundry

automated vacuum packing and unpacking

linked to calender and clock and is autonomous based on the time you have to chose an outfit.

RFID technology...

Hanger.

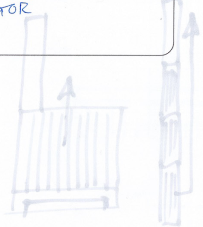


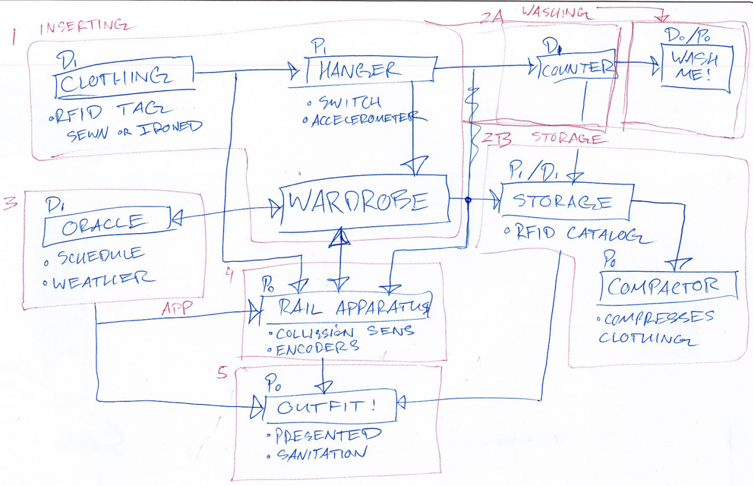
## IoT wardrobe design

**Sensors**
RFID + SCANNER
SWITCH
ENCODERS + COLLISION
ACCELEROMETER

**Data collected and shared**
WORN COUNTER
WEATHER + CALENDER

**Role of the object**
ACTOR






## IoT wardrobe autonomy experience storyboard

1. INSERTING
   - HANG CLOTHING
   - RFID ASSOC. W/ HANGER
   - CHECK COUNTER
     - WASH THRESHOLD
     - STORAGE

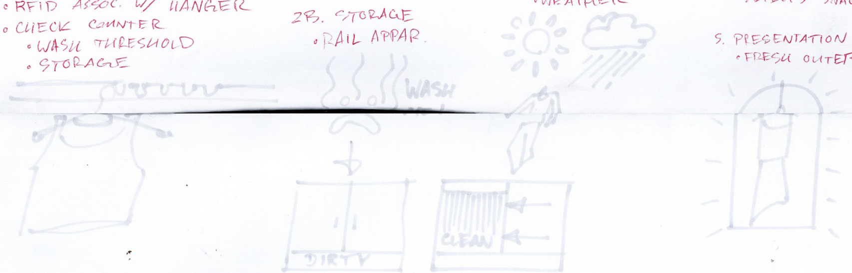
2A. WASHING
   - REJECT ARTICLE

2B. STORAGE
   - RAIL APPAR.

3. ORACLE
   - FASHION SCHED
   - WEATHER

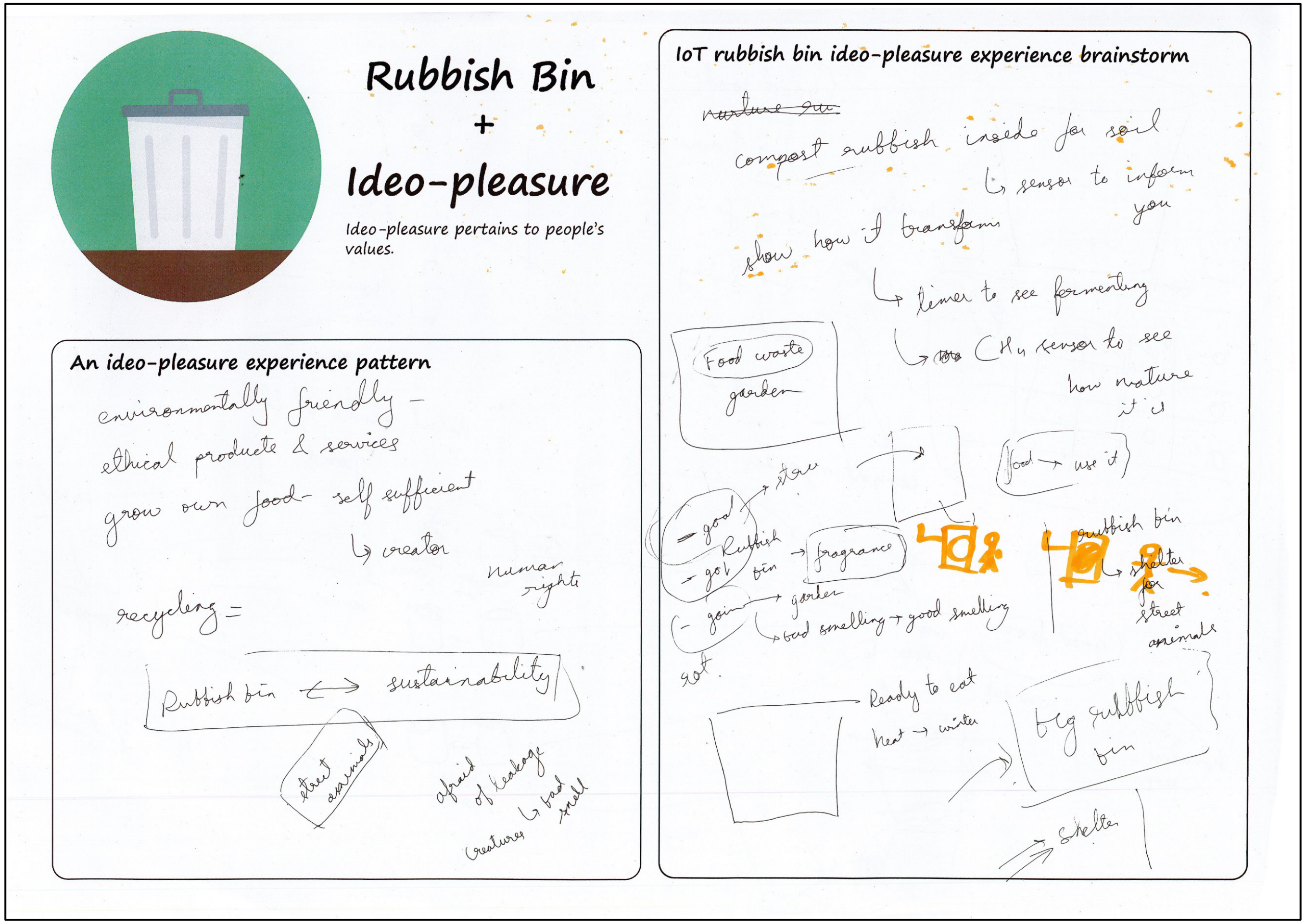
4. RAIL APPAR.
   - MOVE CLOTHING, KNOW WHERE
   - DETECTS SNAGS

5. PRESENTATION
   - FRESH OUTFIT





**Group 5**


Rubbish Bin
+
Ideo-pleasure
Ideo-pleasure pertains to people's values.
An ideo-pleasure experience pattern
environmentally friendly -
ethical products & services
grow own food - self sufficient
creator
human rights
recycling =
Rubbish bin ⟷ sustainability
street animals
afraid of leakage
creatures
bad smell
IoT rubbish bin ideo-pleasure experience brainstorm
~~nature~~
compost rubbish inside for soil
sensor to inform you
show how it transforms
timer to see fermenting
CH4 sensor to see how mature it is
Food waste
garden
food → use it
good
Rubbish bin
fragrance
garden
bad smelling → good smelling
rubbish bin
shelter for street animals
Ready to eat
heat → winter
big rubbish bin
shelter

washing Machine :)

## IoT ~~rubbish bin design~~

**Sensors**

**Data collected and shared**

1. color
2. fragrance.
3. temperature.
4. frequency
5. identity
6. Empty

fixed. options
brand.
(specific size)
(weight)
7. style

**Role of the object**

social connection
Mediator

## IoT rubbish bin ideo-pleasure experience storyboard

# Appendix L. Workshop 3 Feedback Questionnaire

## Designing Pleasurable Experiences by IoT Transformations Workshop Feedback

Dear Participant,

Thank you very much for participating in today's workshop! I hope you enjoyed it!

I would appreciate it if you could provide some feedback regarding *the IoTT for PLEX Framework* and the workshop by answering this questionnaire. It will take about 15 minutes to complete. If you have any questions, please do not hesitate to contact me.

Thanks again for your participation!

Best wishes,

Jerry Zidong Lin

### Section 1. Basic Information

**Q1. Gender:**

☐Male ☐Female ☐Non-binary

☐Prefer not to say ☐Other_________

**Q2. Age Group**

☐18-25 ☐26–35 ☐36–45 ☐46–55 ☐56-65 ☐ Above 65

**Q3. Nationality:**

**Q4. Which programme are you from?**

☐MA/MSc IDE ☐MA Design Products ☐PhD/MPhil Design Research ☐Other________

**Q5. Do you have experience working on IoT projects before?**

☐Yes ☐No

### Section 2. Workshop Feedback

**Q6. Which task did you work on?**

☐Jug blender ☐Lamp ☐Washing machine ☐Rubbish bin ☐Wardrobe ☐Teapot

**Q7. How do you feel about the level of the difficulty of your task?**

☐Extremely difficult
☐Very difficult
☐Slightly difficult
☐Neutral
☐Slightly easy
☐Very easy
☐Extremely easy

**Q8. Do you feel you have learned something from today's workshop?**

☐Yes ☐No ☐Hard to say

**Q9. How effective do you think the introduced framework is in your experience design process during the workshop?**

☐Extremely ineffective
☐Very ineffective
☐Slightly ineffective
☐Neutral
☐Slightly effective
☐Very effective
☐Extremely effective

**Q10. How difficult was it for you to choose the proper sensors embedded in your product?**

☐Extremely difficult
☐Very difficult
☐Slightly difficult
☐Neutral
☐Slightly easy
☐Very easy
☐Extremely easy

**Q11. How difficult was it for you to identify the role (the Collector, the Actor or the Creator) of your IoT product?**

☐Extremely difficult
☐Very difficult

☐Slightly difficult
☐Neutral
☐Slightly easy
☐Very easy
☐Extremely easy

**Q12. How difficult it was for you to decide the data your IoT product collecting and sharing?**

☐Extremely difficult
☐Very difficult
☐Slightly difficult
☐Neutral
☐Slightly easy
☐Very easy
☐Extremely easy

**Q13. How difficult was it for you to design the interactions of your IoT product within a network?**

☐Extremely difficult
☐Very difficult
☐Slightly difficult
☐Neutral
☐Slightly easy
☐Very easy
☐Extremely easy

**Q14. How difficult was it for you to understand the table presenting the interactions with the IoT system?**

☐Extremely difficult
☐Very difficult
☐Slightly difficult
☐Neutral
☐Slightly easy
☐Very easy
☐Extremely easy

**Q15. When you designed the interactions of your IoT product, how helpful was the table presenting the interactions?**

☐Extremely unhelpful
☐Very unhelpful
☐Slightly unhelpful
☐Neutral
☐Slightly helpful
☐Very helpful
☐Extremely helpful

**Q16. How difficult was it for you to summarise a experience pattern of the given pleasure/psychological need?**

☐Extremely difficult
☐Very difficult
☐Slightly difficult
☐Neutral
☐Slightly easy
☐Very easy
☐Extremely easy

**Q17. How difficult it was for you to design a pleasurable experience for your product based on your summarised pattern?**

☐Extremely difficult
☐Very difficult
☐Slightly difficult
☐Neutral
☐Slightly easy
☐Very easy
☐Extremely easy

**Q18. Do you think the framework introduced in today's workshop can improve your future design practice on IoT?**

☐Strongly disagree
☐Very disagree
☐Slightly disagree
☐Neutral

☐Slightly agree

☐Very agree

☐ Strongly agree

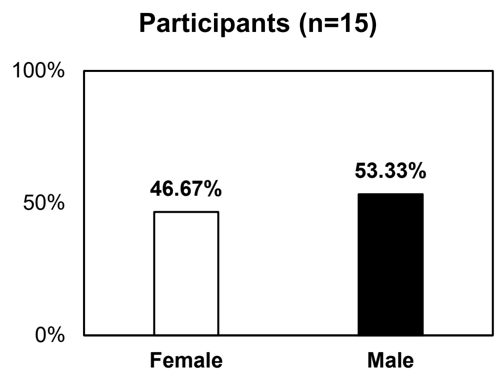
**Q19. Any other comments on the framework introduced in the workshop?**

**Q20. Any comments on experience design of IoT product**

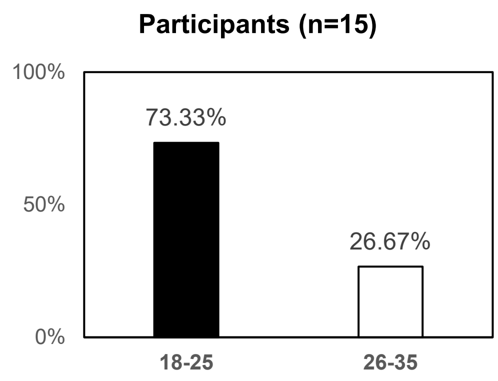
# Appendix M. Workshop 3 Feedback Results

## Section 1. Basic Information

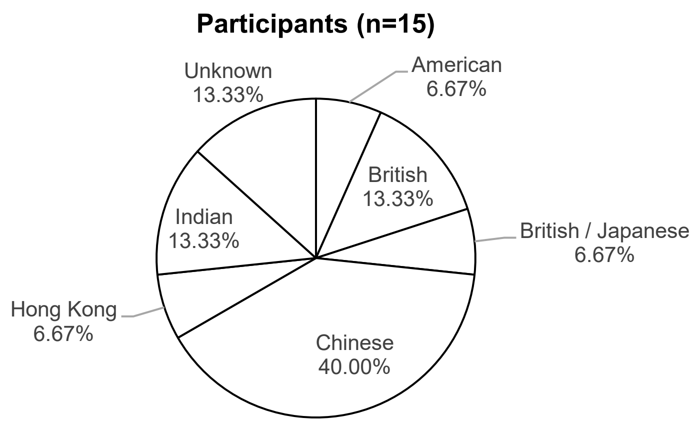
### Q1. Gender:



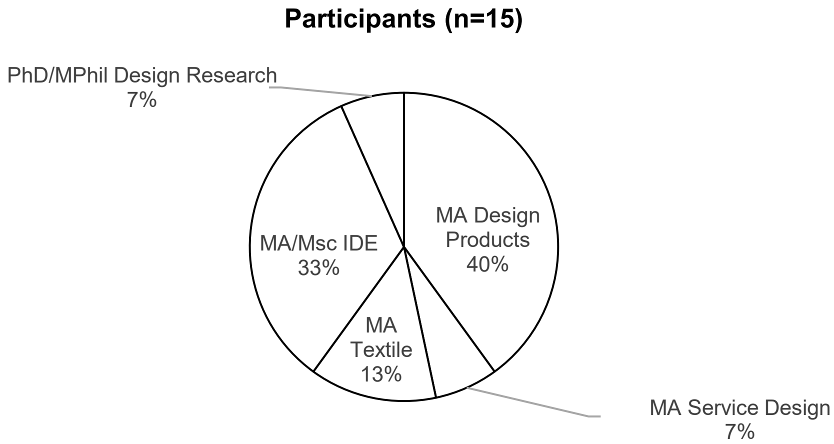

### Q2. Age Group



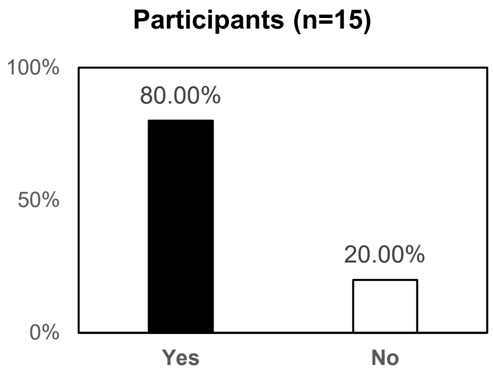

### Q3. Nationality:




### Q4. Which programme are you from?

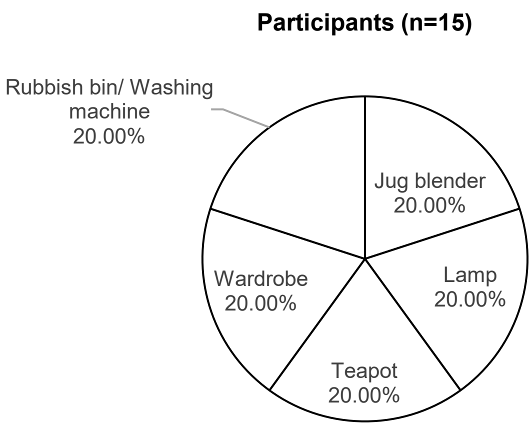



**Q5. Do you have experience working on IoT projects before?**

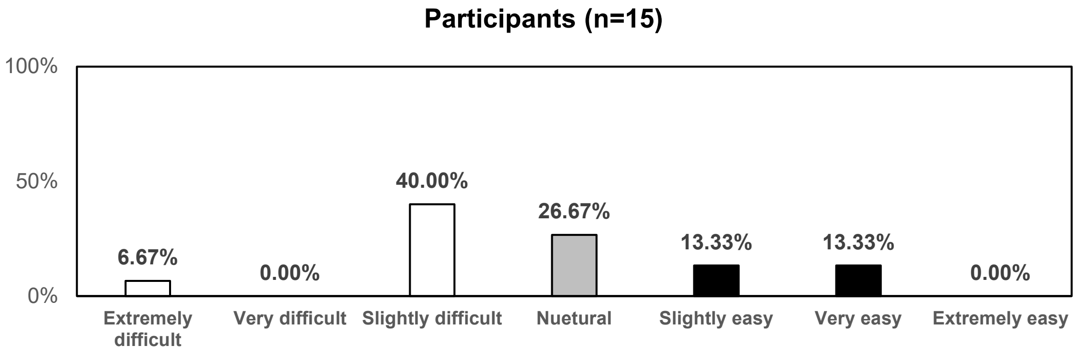



## Section 2. Workshop Feedback

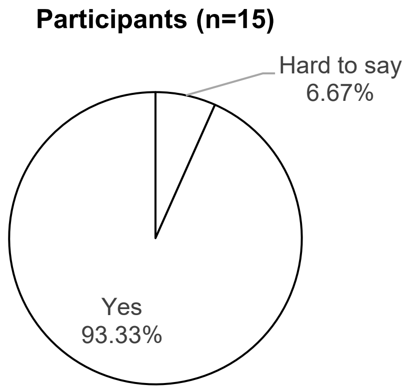
**Q6. Which task did you work on?**



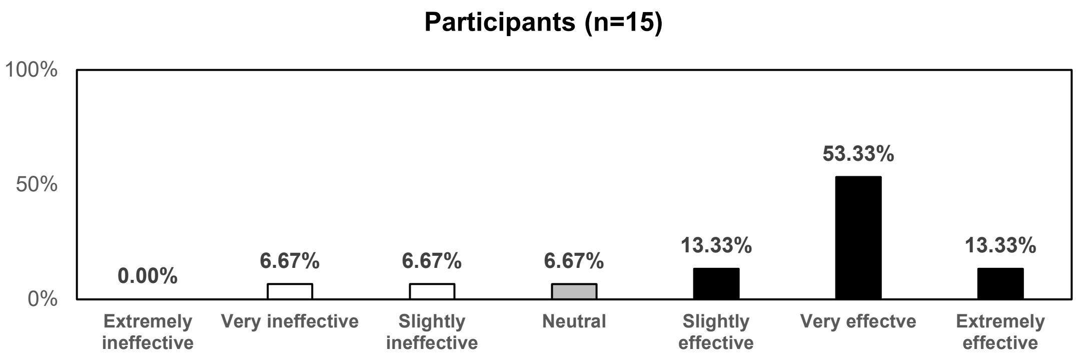

**Q7. How do you feel about the level of the difficulty of your task?**



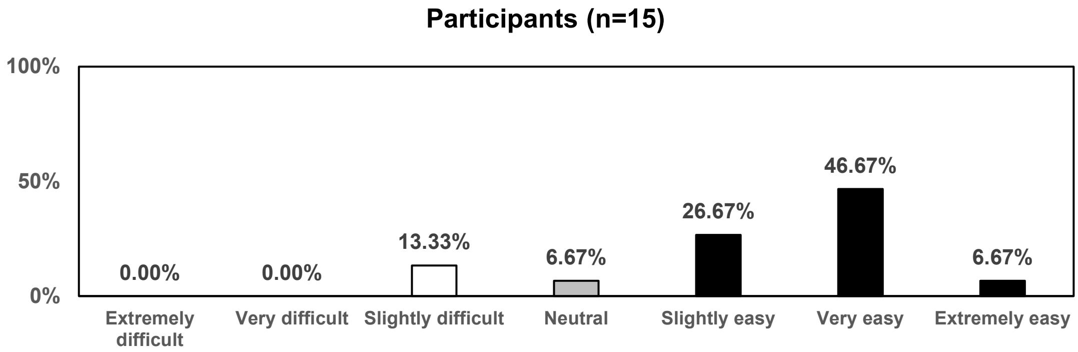

**Q8. Do you feel you have learned something from today's workshop?**



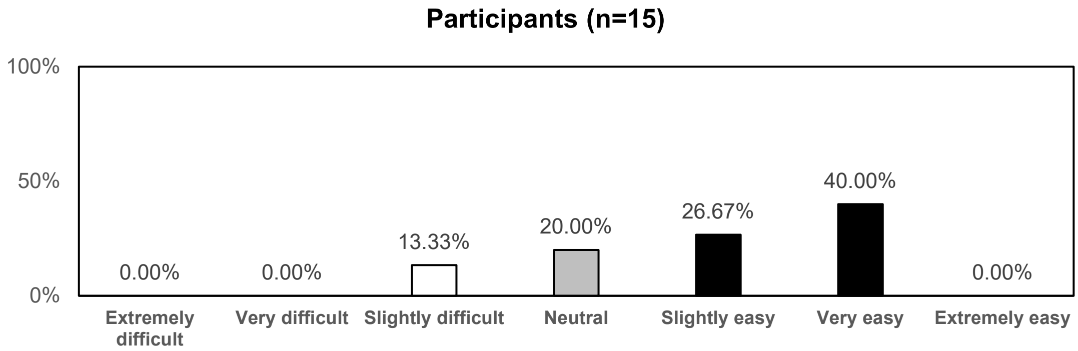

**Q9. How effective do you think the introduced framework is in your experience design process during the workshop?**



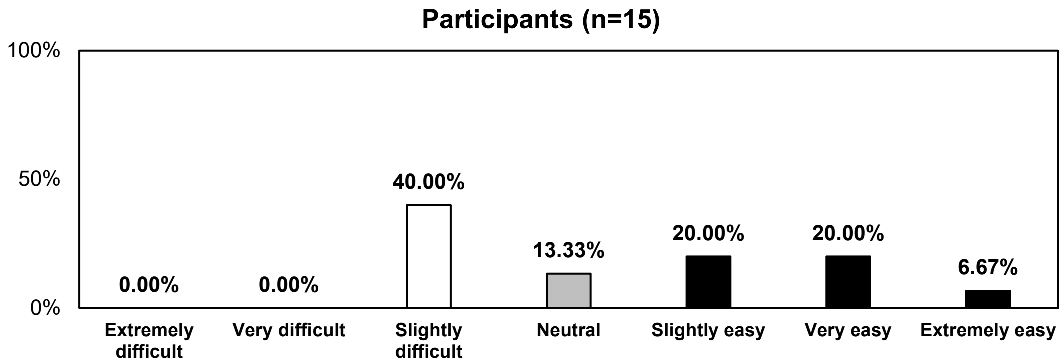

**Q10. How difficult was it for you to choose the proper sensors embedded in your product?**



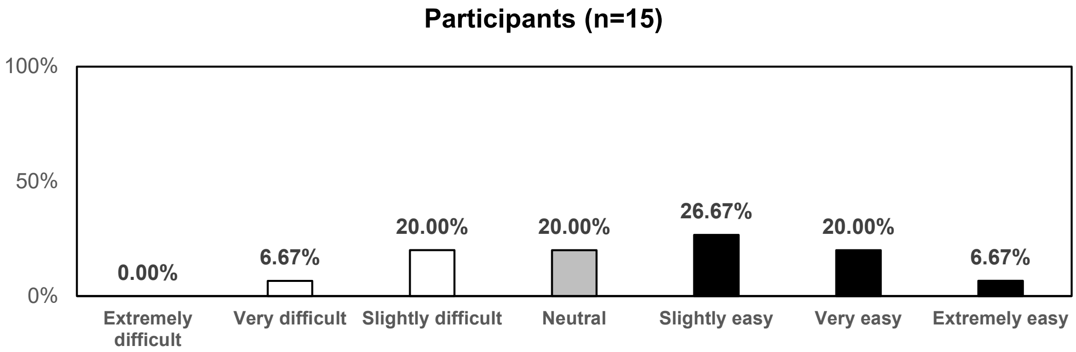

**Q11. How difficult was it for you to identify the role (the Collector, the Actor or the Creator) of your IoT product?**



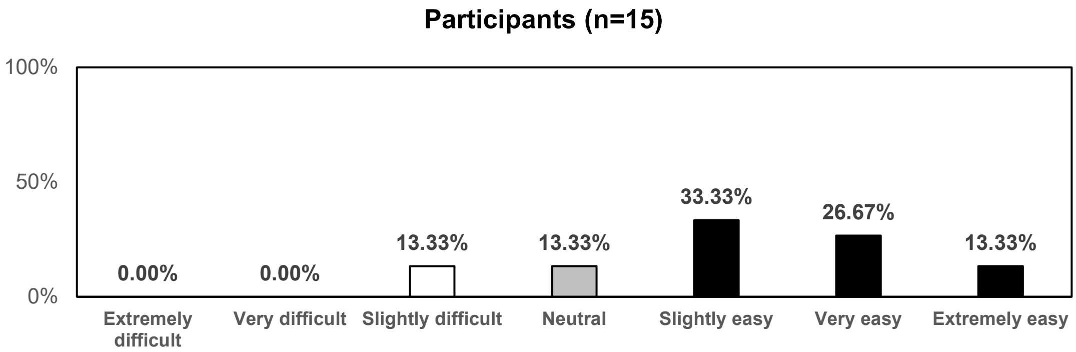

**Q12. How difficult it was for you to decide the data your IoT product collecting and sharing?**



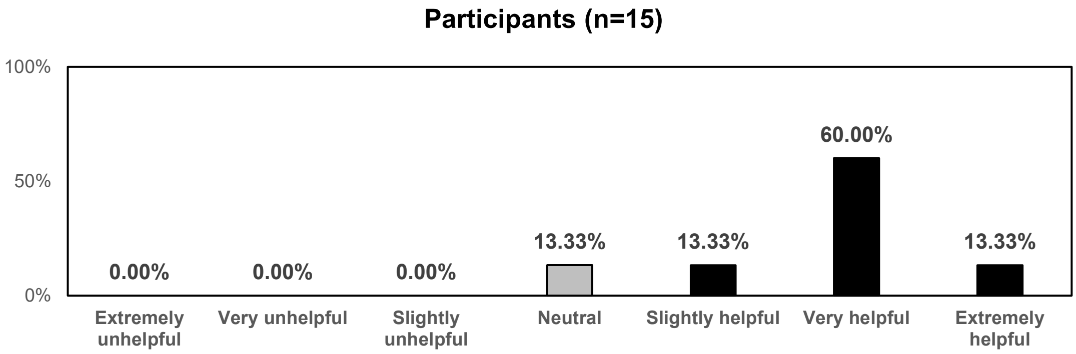

**Q13. How difficult was it for you to design the interactions of your IoT product within a network?**



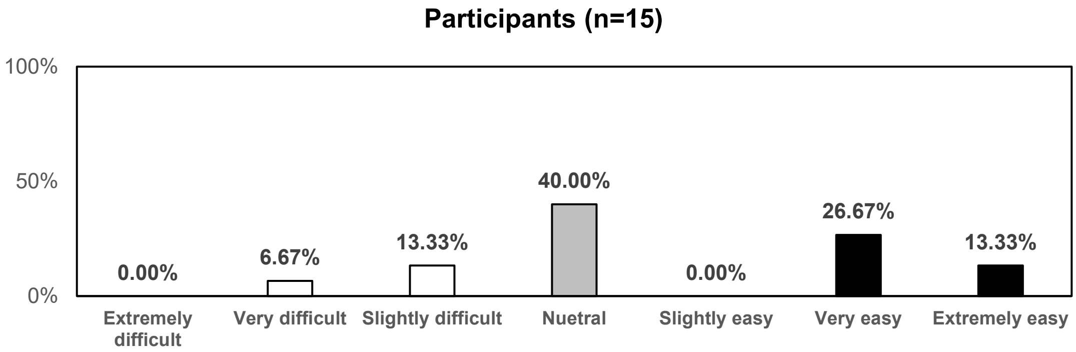

**Q14. How difficult was it for you to understand the table presenting the interactions with the IoT system?**



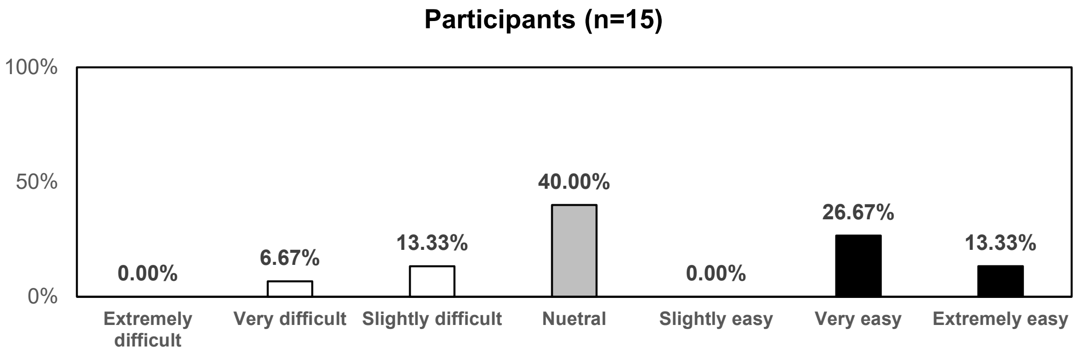

**Q15. When you designed the interactions of your IoT product, how helpful was the table presenting the interactions?**



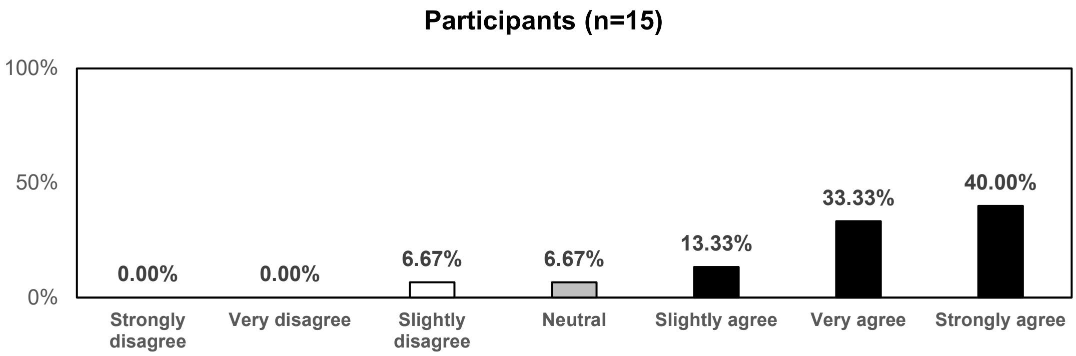

**Q16. How difficult was it for you to summarise a experience pattern of the given pleasure/psychological need?**




**Q17. How difficult it was for you to design a pleasurable experience for your product based on your summarised pattern?**




**Q18. Do you think the framework introduced in today's workshop can improve your future design practice on IoT?**




**Q19. Any other comments on the framework introduced in the workshop?**

| **Participant ID** | **Answer** |
|---|---|
| **P1** | it is great, very helpful |

| | |
|---|---|
| **P2** | The framework itself is very clear and generative and easy to use. However, it is very pleasure-centred so I am not sure how helpful it will be if goal of the IoT system to be created is not all about creating pleasure experience. In addition, I observed that the design process from outlining experience pattern to adding feature to define interaction is quite linear, one direction and seems with no possibility to go back. It will be nice to see maybe a bit more organic or circular process. |
| **P4** | Very useful framework that codified IoT in a way that focused on the emotional human experience |
| **P5** | IoT is an emerging field in the future as it plays an important role in our life, I believe this is an amazing workshop which gives me a sense of reflection and learned a lot.<br><br>Firstly, in the presentation part, I would like to suggest adding one or two 3d demonstration aid to understand the definition of IoT, and adding several videos (short movies) for the IoT case part as well aiming to enhance the visual impact of this keywords. especially when you talking about a new keyword like SPIME, please explain more about what is the relation between the IoT and SPIME. (It might include more pics or videos supporting understanding, just in case audiences are lost and confused.)<br><br>Secondly, in terms of the Workshop Feedback, I think this is a really strong part as we have the opportunity to discuss together how to proper sensors embedded in a common product and identify the role, at last, linked it to IoT through the whole cooperation process. |
| **P10** | The framework doesn't start with a problem so it's hard to articulate what we are really solving for and if there is a need for IoT to intervene in the problem area. |
| **P12** | The framework was extremely helpful. Especially the parts that are related to the psychological needs and relating it to the function of the device. I had never thought about the 3 roles before. |
| **P13** | Great cohesive workflow! |

**Q20. Any comments on experience design of IoT product**

| Participant ID | Answer |
|---|---|
| **P1** | I think more case study or introduce existing/ traditional patterns, or additional theories will add into the diversity of the design methodology. |
| **P4** | Would be great to have some more technological knowledge at some point! |
| **P5** | I think this is an amazing experience when all of the daily products become smarter. I had a deep reflection on how to build communication with other people when we design the Jug blenders, making pleasurable experiences while using things. Especially, we have to consider the important part like interactions between humans and objects, (social pleasure). We got a new communication way when we design the share recipes with our remote friends through IoT jug blenders, from the empathetic methodology, our emotion bonding together, which is amazing experiments |
| **P13** | Despite having my reservations about the concept of IoT as a whole the workflow provided a good glimpse in how to create more meaningful interactions rooted in human behaviours and functional patterns, rather than solutions in need of a problem. |

# Appendix N. Workshop 3 Interviews

The interview audio recordings were transcribed using Otter.ai. Transcriptions were lightly edited to maintain anonymity, correct minor grammatical errors, and complete incomplete sentences only where the intended meaning was clear. All edits were made to improve readability while preserving the original spoken style and meaning.

**Q1. What was your understanding of "pleasurable experiences" before applying the framework?**

**P2:** I think the first thing is about aesthetics. If it visually aligns with my definition of beauty, I find it pleasurable. Especially with animations, when I trigger them and each interaction reveals a new image that matches my aesthetic, I find the experience very pleasurable. Moving on, beyond the basics like avoiding lag, aesthetics come into play. When talking about beauty or aesthetics, it often relates to screen-based UX. But when it comes to IoT and what's considered pleasurable, I think it leans more towards the social aspect. For instance, it acts as an intermediary, like when I'm playing with my siblings, and I can instantly get it to play a song, or when a younger child in the family is fussing, and I can put on a movie or songs they like. It helps alleviate some of my stress, right? Or it contributes to our activities at the right time, which I find quite pleasing. But then, I feel this also ties back to functionality—it seems to be related but not entirely. I mean, UX does involve functionality, right?

**P12:** In my experience, I was probably more just thinking about the interaction itself or the interface — what you're touching or feeling in that experience. But I didn't have a framework mindset to it per se; that was kind of a nuance between before and after. I think in my experiences, I would have looked at things along the lines of a net promoter score for a digital product, which is like the number of people who liked it versus didn't like it — that kind of numerical metric. Or I might have looked at raw data metrics, such as the amount of time they're using it, or whatever the conversion goal is — do they keep using it, do they stay subscribed, or do they unsubscribe? Those sorts of usage metrics are more at the second level.

**P14:** I believe that the "pleasurable experience", as I understand it, falls under the domain of emotionally designed frameworks, encompassing emotional design and user experience. Emotions may include pleasure, empathy, and various other moods, with pleasure being one of these components. Moreover, pleasure can add dimensions and possibilities to the experience, rather than being solely based on the functional aspect of things. This was my understanding previously.

**Q2. What new insights or changes in your understanding of 'pleasurable experiences' have emerged after applying the framework?**

**P2:** I think there are some pretty fresh concepts, like competence or security, which I wouldn't have previously included under pleasure. But now, I'm not quite sure if security fits as a pleasure because, well, my field isn't cybernetics, so there's a lot of this kind of mental philosophy that's similar. Some psychological states are like a steady state, right? Some IoT stuff helps maintain my life's stability and psychological steadiness. Like, when I'm feeling threatened, the reassurance it provides doesn't exactly feel pleasurable; it's more about maintaining stability in my life. But I do agree it's a psychological need. It's more about the definition, and I'm just sharing my feelings here. Competence, I'm not sure why it's considered a psychological need, and the same goes for autonomy. As for the rest, when you present this as a model of psychological needs, I get it, and I agree. But it's just one model, right? It makes me wonder about other models and why you're sticking to this one specifically. Sure, you have a preference, but I feel like you haven't fully explained why you chose this model or sold it to me convincingly. If I'm a design practitioner, I'm not sure why I must use this particular set. Regarding pleasure, it's good to know, I guess. When designing experiences, especially if I were a game designer wanting to bring joy, and then I find out competition or popularity can bring pleasure, I'd use it, right? Sounds good, so why not go for it?

**P12:** Yeah. So what I liked about using the framework was, I remember looking at this and thinking about this after the workshop. I think, like, I love systems design and process design. So I think having a process for doing these things is super valuable in the framework. I think it's a good way to break down important features and nice-to-have features. I think that was one thing that your framework helped someone do, because people just list out all these features. You see it on Kickstarter all the time — like, here's a water bottle that connects to the internet and does all these things. But then it's like, all those features sound great, but what do they actually do? Having a framework, I think, is a good way to design that object, but also to test that object. Yeah. Because the problem is, yeah, like I have a smart toothbrush, but I've never connected it to my phone or my app, because I'm going to use the same amount of time I've always used. I just wanted a smarter one because it's got a couple of other features. But if they were able to have a framework, there might have been something else that would have been a feature that I actually would have cared about. So I think the framework's helpful in creating those features, but also knowing how to test them. I think, to your point on the psychological needs, that another framework is mostly centred around the creation, but it also gets used when testing it or figuring out why a product wasn't successful. I think your framework could be applied to it.

**P14:** Like you mentioned, these types of pleasure and psychological needs, it's like they're expanding on the concept of "pleasurable experiences" even more. They include different categories, like psychological, physical, and then ideo-pleasure, which is super interesting. From my understanding, it might mean that when you have new ideas, or a new understanding of something, or you see more possibilities for something's development, it brings you a kind of surprise and pleasure. I feel like the framework allows me to refine and expand the concept of pleasure even more. I think this detailed psychological theory is necessary because if you just talk about a pleasurable experience, most people might only think about smooth functionality and some fun interactions, or maybe a sense of accomplishment at the end. But if you introduce a framework, it could expand their imagination and might also give designers more directions to explore. When I was studying architectural design, I also looked into how pleasure plays a role. Like, when exploring how spaces are put together and how people interact with those spaces, we'd discuss psychological needs. This included how the dimensions of a space can affect someone's pleasure and comfort, or what kind of psychological effect different spatial dimensions can have. Take Roman temples for instance; they make humans seem smaller and the spaces larger, which kind of instils a feeling of awe and grandeur. In spaces meant to be more liveable, everything might be designed to align more closely with human body scale, making actions like sitting, standing, or using objects in the space feel more comfortable. These considerations are based on psychological analyses of pleasure. And yeah, these ideas get applied in design, but it's not like there's a strict framework or system that everything directly corresponds to.

**Q3. What was your understanding of "IoT products" before applying the framework?**

**P2:** I'll start with this: my background is in researching IoT, so my understanding is kind of like what's commonly understood in the field. I think the general trend in design is about automating existing tools, which is what the IoT community is eagerly adopting. For instance, turning a lamp into an IoT device because a lamp is a tool that requires effort to use, but if it's automated, then you don't need to put in that effort. This fits perfectly with the discourse from the 60s and 70s about a service economy that's efficiency-driven and aims for seamless integration. I believe this is a stereotype of IoT, the general perception of it. But from my research perspective, I find this thinking too limiting, to the point where I can't imagine anything beyond IoT being just about automation, along with some data collection and visualization. It essentially boils down to data collecting, either acting on its own or visualizing the data it collects for you, which I find quite boring. The boring part is that it seems like there's no new possibility, but I personally think the root issue is with the framework itself. You can't just think of IoT in terms of automation. As for whether I've figured out an alternative, I haven't yet, to be honest.

**P12:** Yeah, I think… I guess I had exposure to that word, so I did already know what it was. But in a broader context, I think of all the little sensors. I mean, first of all, I think of sensors. My first thought was your first role or first archetype of the collector, that kind of thing, mostly because I don't have too many of the second or third examples. My wife used to wear an Apple Watch, but I think she's a good one. And I'm trying to think of what else… I have a sleep tracker, we have an AI, we have a smart dishwasher. I think in my head, I thought of IoT mostly as sensors and those types of things. Maybe I think of a Nest thermostat as one of those. And we have the Hue light bulbs. I think that's probably the only IoT device that I fully use every single day, like a data capture piece. I think they include more things now that I think about it, but I probably would have quickly just thought of all the sensors connected to the internet somewhere. Mostly we think of cameras, temperature sensors, humidity sensors — that kind of thing. I think that would have been my answer.

**P14:** My understanding before was that in a large system, whether it's a city or a home environment system, there are a lot of sensors. These sensors collect data and then transmit it to a main host, allowing the data to flow. Then, different reactors respond in a coordinated way, making the whole experience for a person in that space smoother. It involves system infrastructure, data-collecting sensors, and basically, that's what I thought it was all about.

**Q4. What new insights or changes in your understanding of "IoT products" have emerged after applying the framework?**

**P2:** My feeling at the time was because the aspects you introduced, like the division into sensing, connecting, and actuating, weren't new concepts, right? And the same goes for the relationship and interactions between people and technology; none of it felt new. So, during the workshop, my focus was on how to use the existing model to generate pleasure, but I didn't get the impression you were introducing a new framework. You didn't show me that IoT isn't just about this. There seemed to be no novelty in that part, but the freshness in the aspect of pleasure and some of the needs or user-end stuff you mentioned did seem to introduce something new. So, it didn't change my understanding of IoT.

**P12:** Two things I think changed. One is thinking about them as devices that interact with other devices. I think that was one important thing in my head. Even if it wasn't necessarily connected to the internet, I initially thought it needed to be something connected to the internet that I was using. And then I think you reminded me of other examples, where it's like objects interacting with other objects, and maybe that's as simple as, in this building, the lights or motion sensors are activated after 6 p.m., thinking more of those types of examples. I think that helped me. And then also thinking of the third use case of choosing interactions between humans mediated by objects, I think that's another one that makes sense. So I think that's one thing that I thought was interesting. And then I think the other way of thinking, the agency, or level of agency, or level of control, was something that I broadly didn't really think about. People think of IoT as a very cold, concrete world, and I think this idea of bringing in the framework of pleasure and psychological needs is quite valuable.

**P14:** I think the human factors should be included as well, meaning the system isn't just about sensors, data-collecting devices, or infrastructure; it also considers people as part of the system. I believe the physical stuff, like the sensors and devices that output information or interact, along with algorithms and big data analysis, are mainly about processing this information. They aim to find insights based on this data and then have the physical components respond based on these insights.

**Q5. How do you translate the psychological needs/ pleasures learning from the framework into your design concept?**

**P2:** First of all, it felt like building with blocks because you gave us some basic parameters, like thinking in terms of actuators, sensors, or networks. I think we started from there, wondering how to integrate elements of competence. Our general approach was to think about the context of something like a lamp. Where is it situated? Either in an office or your study space at home, which is pretty straightforward. These are places where your capabilities are demonstrated, and then sensing is about how the object understands you. For instance, if you talk about an iWatch, how does it understand your physical activity? So, we wondered if sensing could grasp your work performance, and after understanding that, it moves to actuation, as in how it behaves, right? Then it's about how it matches up, but to be honest, I wasn't entirely focused on the lamp's behaviour at the time. Personally, I think IoT has a problem where if you just insert IoT capabilities into existing objects, the range of behaviours is quite limited. What can your lamp do? As an agency, it can move, maybe nod or swivel, and light up. But lamps are stationary; they can't move, so we could only add to its complexity, like with mini lamps because then you can move around, escaping the stationary state. But then, a lamp's actions are extremely limited; it can only illuminate. So, we focused on colour, but colour can also serve as a form of expression. That was our output. The form we designed was actually a medal, which is all about whether you want to achieve something. I think you have to examine whether it's capable, possibly in a quantifiable way. Its outcome is quantified, not so much about keeping records, but more of a show-off thing. Because, in essence, our whole design concept was very much about self-care.

**P12:** If I remember correctly, I think we had a few concerns, broadly speaking, about why we would want a smoothie or shake and what we wanted out of it, and then how we could make that a better experience. I think one of the points was that smoothies tend to either be very thick or very runny, so the experience of having a smoothie—the consistency—was an important factor, regardless of taste. Being able to control that speed is something that the blender could solve. Blenders have been around forever, and you can go from one speed to two speeds, three speeds, four speeds for different advice. You can control the time manually, but people still are not happy with their smoothie. So the question was, could you have a machine with just a little more information to make that decision for you? I think that was why we said it was about control—how to make the perfect smoothie is what makes you feel like you're in control. And then being in control is what we thought of as safety. The second piece was: how do we make that smoothie better? So it's about the recipe and nutrition. Most people are taking smoothies either after working out or before working out, and they want to make sure the nutrition is good, which is something no blender has ever provided. The other part of that was just knowing what's put into it. I think that's when we started talking about another project, where it was like: how could this blender relate to a refrigerator? How could you know what ingredients you have? That sort of thing. I think this was a testament to the framework because it led not only to features of this product but also gave us the idea for another IoT device that could work with it. That was the fridge—a smarter, more connected fridge. One really cool thing about your framework is that it helps with the features of one object but might also help with creating more objects and a community of objects. I think we even sketched a fridge and thought, "Maybe this isn't just about the blender—it's about the fridge. And does the blender need to be a blender? Or could the fridge actually be the blender?" I think that was interesting. We ran out of time, but I think it would be a really cool follow-up. If the workshop were two days, the framework could help you refine the blender project, and then you could also create a whole guide for designing another object to interact with it.

**P14:** Firstly, we focused on autonomy because we want to predict the nutritional needs for a smoothie based on someone's physical state and recent activities, like their temperature preference and texture. So, this means the machine would automatically tailor its responses to how the user is feeling. The big picture is, it uses your health data to produce the perfect smoothie that meets your needs right then and there. I think this gives a greater sense of control over life, making you feel happier and healthier through this process of collecting data and making the smoothie automatically. And by sharing, it's about boosting life quality for others too, making everyone feel good and in control. It's like, because I'm doing healthy stuff and eating healthy, I feel like I've got a grip on my life, and it's heading in a positive direction, rather than being clueless about what I'm eating. Or it's like the machine helps you be more disciplined. We've got this guy in our group who's into fitness and often makes his own smoothies. He was saying that, from his experience, the trickiest part to nail down, or the part where he feels like he's not in control, is not knowing the exact fruit to milk and water ratio. So, his smoothies come out different each time, sometimes too runny or too thick, which he's not a fan of. That was a big part of our thinking. So, it's like, because the sensors can weigh every ingredient we put in, they can then calculate to get the consistency and texture of the smoothie just right. We were thinking of connect it directly to the fridge, so the ingredients from the fridge could automatically be dropped into the blender. This way, by precisely controlling the proportion of each ingredient, you'd achieve the desired texture and state more effectively. That was our idea for controlling the smoothie's texture. And then, we thought about connecting it, say, to your smartwatch, linking up with the smoothie machine to collect your health data and predict the nutrition you need based on that. Compared to a traditional blender, our idea leans more towards being smart. It can precisely control the texture of your smoothie, which is tough for people to get right—you'd normally have to guess how much milk you've added, and how many veggies or fruits. The smartness comes from the machine's precise control, ensuring the texture is just right. And sometimes, people don't know what nutrients they need, especially after certain activities. Like, after a workout at the gym, you might be low on fluids and salts. The connectivity aspect mainly enhances convenience; your fridge could directly feed ingredients into the machine, so you don't have to manually add them yourself.

### Q6. What is the most difficult part for each step in the IoTT for PLEX Framework?

**P2:** There wasn't any difficulty, but it felt a bit like filling in the blanks, you know? It felt too smooth, almost as if I could directly apply what I already knew, rather than needing to explore something new. Actually, the step-by-step design process is relevant. For instance, at the beginning, our scope was quite broad because you hadn't assigned our object yet, so we ended up discussing what competence is extensively, including whether you could contribute to society, which we also considered as a form of competence. But once we got our specific object, the scope narrowed down immediately to the lamp and competence. The scenario where the lamp is used, which is work, is the most fitting, limiting competence to work ability or capacity. Then, it was about reading data, and the best data to read in this context is your work status and calendar, as these are things found in a desk scenario, like your computer. Gradually, it all became very certain, including why a medal was considered based on the object's characteristics, its luminosity. So, we started thinking that just being bright was too limited, so we designed it with many sub-lights, like grandson or son lights, to better showcase and distribute the effect. And why a medal? Well, it's similar to thinking about things like being named the sales champion in a work scenario, where you might get a name card, perhaps with gold trim. It's all about linking up with the visual language commonly found in work environments.

**P12:** Broadly speaking, I think tapping into these pleasure and psychological needs is a more difficult practice. My exposure to thinking about those things comes from conversion optimization in the e-commerce setting. I haven't had that many conversations in a design education setting about them, even though we know they're important. So I think it was helpful that you gave that presentation about those needs. I think that is an exercise that more designers would benefit from—trying out this framework to examine needs and the psychological aspects. How to test them, I think, is another research interest and another question. How would we test them? I think that last part is difficult if the practical human behaviours are different from the behaviour we're trying to encourage in this context. Nobody in my group had ever shared a smoothie recipe, but we had all consumed a recipe, or we'd seen a recipe on Instagram, Google, or elsewhere. So I think the hardest part of this one is if you're creating a new behaviour that people haven't done before. None of us had shared smoothie recipes. If we'd had more time to think on that one, maybe it wouldn't have been that complicated. But I do think that's probably one of the harder ones. I think choosing the sensor was partially difficult because we know that the data we really need is not usually the data we think we need. For someone who doesn't know the value of the data, I think it's the hardest example to pick data for. From my digital experience, for example, we can figure out the number of people that like your website based on the amount of time they spent on it. That's not necessarily going to match the number of people who click "yes" on a survey, but you might not have realised that's the metric you needed. I also wonder if it's just difficult now because people don't yet have a quick understanding. Whereas, say, a year or two from now, this information might be much more accessible. Or the data values might be clearer. Or there might be more tools that say, "If you want to collect data for autonomy, these are the 10 variables you want to use." If there's a general knowledge base for everyone in this space, that will probably be better in two years than it is now. I'll give you a good example of something like this. In art education, they'll teach you colour theory, for example. They'll say red is going to give this impression, blue will make someone feel like this, and green will make someone feel like that. So if you're making a painting or creating something, you should make it this colour. That's something every artist learns and then incorporates into their work. I suspect that type of education could become more prevalent in the field you're exploring. Maybe that would make it easier.

**P14:** I think the tricky bit for the first step might be defining what exactly these various pleasures are in specific scenarios. They're still quite broad concepts, but in specific situations, each different need might vary. Like, the kind of pleasure you get in a sports setting, at home, or in a transport scenario, the proportion of each type of pleasure could be quite different. For the second step, I think it is the issue of agency. Because when we discussed it, we mentioned that if something is too proactive or too smart, it might actually scare people or make them uncomfortable. Our aim is to enhance people's sense of control over their lives, but if an object is overly intelligent, it might diminish that sense of control, making users feel not so great. So, balancing and managing the level of an object's agency could be quite tricky. It might be necessary to set up some specific scenarios and let users say what feels right and what doesn't.
For the third step, we started with the simple design of the interaction between people and the blender. We were thinking about how to make the user experience smoother and more convenient from that base. Then, the idea of the fridge directly supplying ingredients came up, which could eliminate a step in the process for people. Finally, we discussed how to build a social type of pleasure, like incorporating a sharing feature. The challenging part might be in these interactions, especially whether they're truly necessary in that scenario. Like, do people really want to share, or are they actually reluctant or see no need to share? Also, every time you build a community, there's a cost to maintain and design it. Whether it's really necessary is key. I think these interactions could vary in their sequence depending on the scenario, but in this context, it's more about whether there's a need for such features.

**Q7. What reflections have emerged from your design proposal? Has it prompted you to reconsider the relationship between pleasurable experiences and IoT products?**

**P2:** When you were explaining to me earlier, the whole fundamental idea behind what you're doing is to open up possibilities. I totally understood that you're creating a design framework and that you aim to guide designers. But the design framework you described felt very familiar to me, kind of like the Double Diamond model. For example, when you're doing UX/UI and you're new to the industry, your boss might tell you to create personas, then to map out the user journey.

This feels very familiar. It’s like, first you do this, then you do that, and so on. But I also felt a bit confused, not understanding why the steps should follow in that order. After following your steps, something indeed gets generated. But there were points I didn’t quite ‘get’, like why you start with creating personas and mapping out user journeys, identifying pain points. The framework acts as a guarantee that there will be an output, but you’re always left with some ‘whys’, right? Or ‘hows’. If you don’t tell me why, I won’t know how. This felt very familiar. But at the same time, you say your fundamental piece is about how to open up possibilities, which surprised me. I thought such a framework wasn’t supposed to ensure outputs; it’s not meant for you to randomly come up with other possibilities. So I’m wondering why such a rigorous framework ultimately leads to other possibilities. Unless, of course, if the possibility is something pleasurable, something definite, maybe that’s the kind of possibility you want to work towards. But this is just me sharing my thoughts. Because actually, your entire process is very mature, every step including what to consider and when, is very well-designed and mature. So, my question is, how does such a mature model ensure that possibilities are indeed those alternatives or possibilities?

**P12:** I think the most valuable thing I would do differently now is, rather than mapping each feature to a purpose, I can also map that feature to a psychological purpose, a pleasure purpose, and then also how that could be used in the interaction types. It might also mean that I choose not to have certain features if I don’t want them to have these other interaction types. One feature of the framework is that it doesn’t decide for you if all of these interactions are desirable, or even if they’re positive or negative. For example, an object that allows humans to interact and be mediated by the object could be quite valuable, but in some examples, maybe that’s not as valuable. Think of smart breast milk pumps for mothers—could it be valuable to see interactions between humans? Maybe for a private community, yes, but not for something like Instagram or a public community of mothers. I think the framework gives you that idea of how to prioritize those things, which is nice. For the second point, where you say, “Add sensors, connect to a network”, having that as a process makes it much easier. I think that’s a process people might otherwise have just figured out in their own way when prototyping. And I think the idea of having the pleasurable experience pattern is probably a step most people skip. I imagine if I were to prototype something in a one-day design sprint, I would probably focus only on steps two and three, and not spend time on step one. So I think the qualitative benefit of someone agreeing to use this framework is that you can also map these other aspects.

**P14:** I feel that because we followed the steps of the framework during our design process, it was quite smooth and we could think of quite a few interesting points. Following the framework felt seamless. I think the best bit about this framework is that it's comprehensive, so when you're working through it, you're less likely to miss anything. Of course, some aspects might not apply, and you can weed those out, but overall, it feels quite complete.

**Q8. How would *the IoTT for PLEX Framework* influence your future design practices regarding IoT products toward pleasurable experiences?**

**P2:** Because I feel like when you introduced these psychological needs, it gave me the impression that I could start from psychological needs, rather than from hardware. Many tech companies are ahead in hardware technology, so they tend to create demand based on their existing technologies. But you're starting directly from psychological needs and then working backwards to determine what hardware is needed. I see this as a difference in the process.

**P12:** So again, the positive side of the framework is that it's neutral in the sense that it doesn't seem to favour one type of interaction. I suppose there are some values the framework shares, in the sense that collecting data is useful. Those assumptions, I think, are fine because you just buy into the framework. I think the challenge with the framework, the first one, is that, qualitatively, it's a different kind of thinking. The pleasure aspect is difficult for someone who's never done it before. I think maybe that's not necessarily a weakness; it's just more difficult. The second thing is that because it's a qualitative aspect, it can't always be seen. I think of specific contexts to give you a good example: if a designer was hired to create a prototype for someone who wants to launch a product on Kickstarter, the client would much prefer seeing physical milestones and visible progress. It's harder to measure progress in that first step, which I think feels more like part of the process that an academic would buy into. I don't know how much time you recommend spending on each one of these tasks. In an academic environment, we spend quite a bit of time on those needs. But in a more real-world environment, where there's either a low R&D budget or no R&D budget, people will probably jump to steps two and three, and then work backwards on step one from a marketing perspective. I think that's one of the more difficult parts for someone following the process, but it's not necessarily a flaw in the process itself. I think in real-world adoption, people will skip over that part more than the others.

**P14:** I think the framework covers points in a more comprehensive way. It's actually a step-by-step process, kind of like I've streamlined the whole thing, making it clearer and more distinct. I feel it becomes clearer what needs to be done at each step, what aspects to consider, which might become innovative points in the design.

**Q9. Do you know any UX design theories that you believe might also be helpful for IoT practice?**

**P2:** It's actually quite fascinating, cybernetics and second-order cybernetics also talk about the emotional exchange between people and machines. There are two examples I can think of, one is a blender, and I don't know its exact name, but every time you press it, it emits a scream. And then there's a kettle that's kind of like speculative design; every time you try to pour water from it, it sprays you instead. I think these are purely emotional interactions; they've completely abandoned their functional purpose. So, I guess, I don't really get their value, I just see them as an exploration, but I don't really understand where their value lies. Maybe they could be considered a form of art practice?

**P12:** On the software side, if I mentally think about how I would deploy one of these IoT devices, I guess one of my questions for evaluating the framework is how well it works in an Agile software world versus a Waterfall world. That's less about the actual device and more about building the software infrastructure to support that device. I don't know if this framework makes that easier or more difficult, but that might be one more point of qualitative analysis for you when measuring the framework's effect. It's about how you build software for it. The more common approach now is Agile and Scrum, with a dedicated product owner for both the software and hardware sides. You would be able to look at it this way: those software frameworks require you to define those types of pleasure and how you're measuring pleasure very specifically, which might create more information about how identity and agency could work

**P14:** I think there are some basic UX theories, like the proximity principle, the razor principle and those principles Don Norman brought up. I'm wondering if, for instance, when you're adding IoT features, you could incorporate more modern and advanced elements of IoT interaction, such as gesture interaction and image recognition. Because it feels like multi-sensory features could totally change the way you interact, moving away from traditional interface interactions to more natural language interactions. Like, your natural language interactions or gestures could all be taken into account, which could actually open up many more IoT features.

**Q10. Do you have any ideas for expanding this framework from a designer's perspective? How can it be further expanded?**

**P2:** I think this framework is too refined and too well-designed. It has some points that can be improved, leaving room for us to design. I'm not sure if it's intended for designers or users, but it's quite comprehensive. In fact, the definition is so precise that it feels exceptionally mature. This maturity reminds me of those well-known frameworks in UX/UI history. However, I've always had some minor doubts about those frameworks.

**P12:** In my quick analysis, I think this framework works slightly better for someone developing using a Waterfall method than an Agile method. I don't think that's right or wrong—it's just more attuned to that type of development. So I would look into how Waterfall uses evaluation to figure that out for this framework. The analysis framework, OKR (Objectives and Key Results), is one of the newer review frameworks. Again, I'm only speaking about software, but I think you could take that framework and bring it into this one without making it circular and without having to change much. That might simply come down to: how do we measure, and what are we measuring? In the first example, maybe it's autonomy as a psychological need. How do we measure autonomy? The problem with the blender is that I don't know if it takes away your autonomy or gives you autonomy—and I also don't know how to test that. If I had a one-question test for using the imaginary blender, it might be: "How does it make me feel?" or "Do I have the same feeling every day?" For me, I might feel like I'm getting an hour back in my day. But for someone whose mood changes and who wants a smoothie based on a different mood, the question might be: "Did that smoothie fix your mood, or was it as good as you wanted it?" Coming up with that kind of question might be helpful to add to the framework in that in-between space. The second part is: how do you measure it? Is it simply that it works or doesn’t work? Is it whether it’s good or bad? Or is it about accuracy? What are the qualities?

**P14:** However, I think what’s possibly missing is an evaluation phase. Like, as designers, we might think our design is brilliant, but without user input, we can’t be sure if some of the design steps are necessary or how much they actually enhance the experience. It can actually be integrated with the Double Diamond model, where you can see each phase as a point in the process, allowing for both divergence and convergence. I think it doesn’t conflict with the Double Diamond at all; these processes can totally be combined.

# Appendix O. Workshop 4 Consent Form

**Participant Project Information & Consent Form***

(One signed copy of this form should be retained by the Participant and one copy by the Project Researcher)

*Design Workshop*

*Designing Pleasurable Experience by Transforming Analogue Products into IoT Products Using Attachments*

For further information
Supervisor: Dr Bjorn Sommer
*Bjorn.sommer@rca.ac.uk*

*15/08/2022*

Dear Participant,

*I am Zidong Lin a PhD candidate* in Design Research at the Royal College of Art, and a visiting researcher at Open Lab, Newcastle University. As part of my PhD studies, *I am* conducting a design workshop entitled *Designing Pleasurable Experience by Transforming Analogue Products into IoT Products Using Attachments*. You are invited to take part in this workshop with the aim of getting feedback on IoT concepts for pleasurable experiences and generating new ideas.

If you consent to participate, this will last 1.5 hour and involve three design activities:

- **Activity 1: design relatedness with attachment 1**
  **Attachment 1 for relatedness:** an IoT attachment with a digital sensor which can send the read form the sensor to another same attachment. There are two buttons on it, and an LED light.
  ***Relatedness:*** *Feeling that you have regular intimate contact with people who care about you rather than feeling lonely and uncared for.*

- **Activity 2: design stimulation with attachment 2**

**Research Office** Royal College of Art Kensington Gore London SW7 2EU
t +44 (0)20 7590 4126 f +44 (0)20 7590 4542 research@rca.ac.uk www.rca.ac.uk/research

**Attachment 2**: an IoT attachment making two home appliances compete with each other and stimulate the users. There is a LED matrix on it to express the characteristics of the home appliance.
***Stimulation:*** *Feeling that you get plenty of enjoyment and pleasure rather than feeling bored and under-stimulated by life.*

- **Activity 3: design ideo-pleasure/ meaning with attachment 3**
  **Attachment 3 for ideo-pleasure/ meaning**: an IoT attachment making users compare their energy consumption and save more energy. There is an LCD screen to display the usage, a button for sending signal and an indication led.
  ***Ideo-pleasure:*** *pertains to people's values.*
  ***Meaning:*** *Feeling that you are developing your best potentials and making life meaningful rather than feeling stagnant and that life does not have much meaning.*

Before each activity starts, the definition of each psychological needs and a design idea from the researcher will be presented to the participants (5 minutes). You will be given a task sheet with a list of sensors that are potential to be embedded in the attachments. In each activity, you will spend their first 15 minutes brainstorming what non-IoT products each attachment can be attached to, what other sensors can be embedded in the attachment and how they can fulfil people's psychological needs. In the next 10 mins you will present your ideas and have a short discussion.

We will take some photos to record the process of the workshop. Some scenes might be shown in future published academic papers but in these photos your face will be blurred. The ideas you generated in the workshop might also be presented in the future papers and they might be selected and further developed in my future research. At no time will any individual be identified in any reports resulting from this study. Images or quotes, which may allow you to be identified will only be used with your express permission.

To participate in the workshop, you need to understand and agree that your concepts developed in the workshop remains the property of the researcher (Jerry Zidong Lin) and you waive all rights to him. You are welcome to discuss co-publishing with the researcher for the future papers regarding this workshop.

Participation is entirely voluntary. You can withdraw at any time up to the point of publication and there will be no disadvantage if you decide not to complete the study. All information collected will be confidential. All information gathered will be stored securely and once the information has been analysed all individual information will be destroyed.

If you have any concerns or would like to know the outcome of this project, please contact me at zidong.lin@network.ac.uk or my supervisor at bjorn.sommer@rca.ac.uk.

Thank you for your interest.

I *(please print)* ……………………………….. have read the information above and all queries have been answered to my satisfaction. I agree to voluntarily participate in this research and give my consent freely. I understand that I can withdraw my participation from the project up to the point of publication, without penalty, and do not have to give any reason for withdrawing.

I understand that all information gathered will be stored securely, and my opinions will be accurately represented. Any data in which I can be clearly identified will be used in the public domain only with my consent.

Participant Signature…………………………………………………………………

Researcher Signature…………………………………………………………………

Date: ………………………………………………………………………

**Complaints Procedure:**

This project follows the guidelines laid out by the Royal College of Art Research Ethics Policy.

If you have any questions, please speak with the researcher. If you have any concerns or a complaint about the manner in which this research is conducted, please contact the RCA Research Ethics Committee by emailing ethics@rca.ac.uk or by sending a letter addressed to:

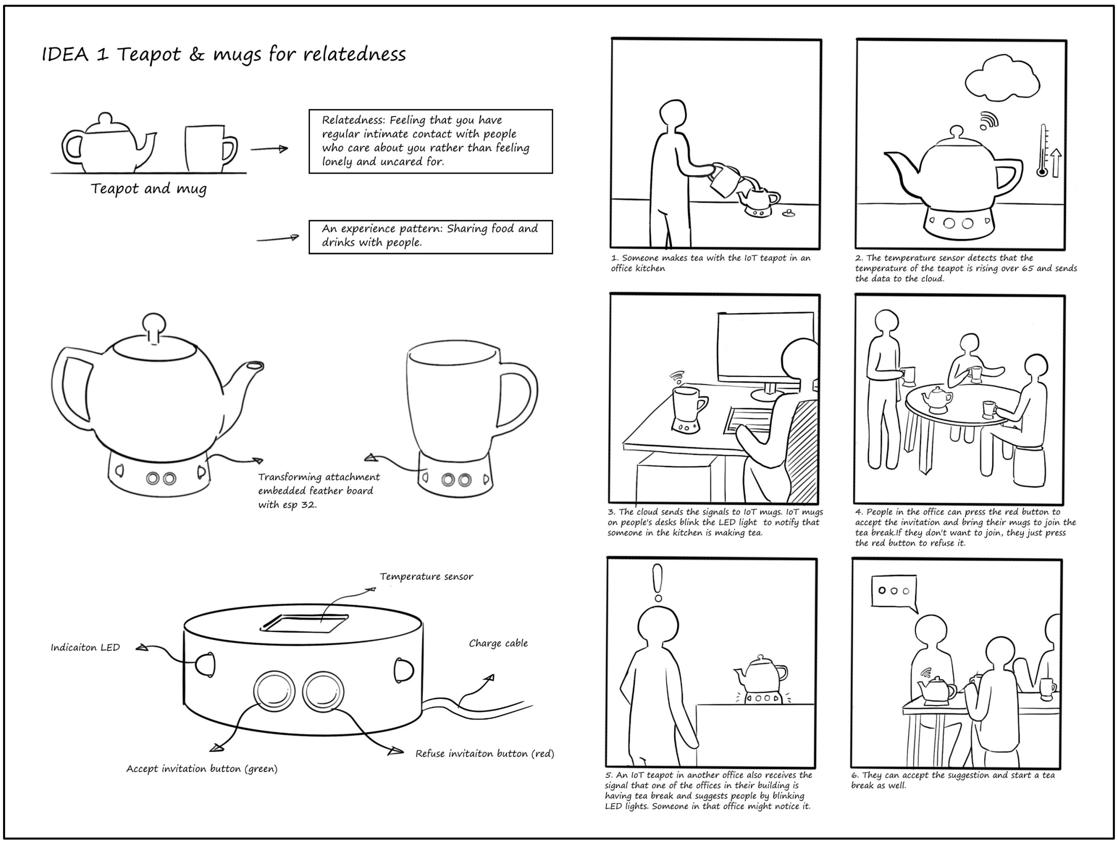
The Research Ethics Committee
Royal College of Art
Kensington Gore
London
SW7 2EU

# Appendix P. Workshop 4 Results

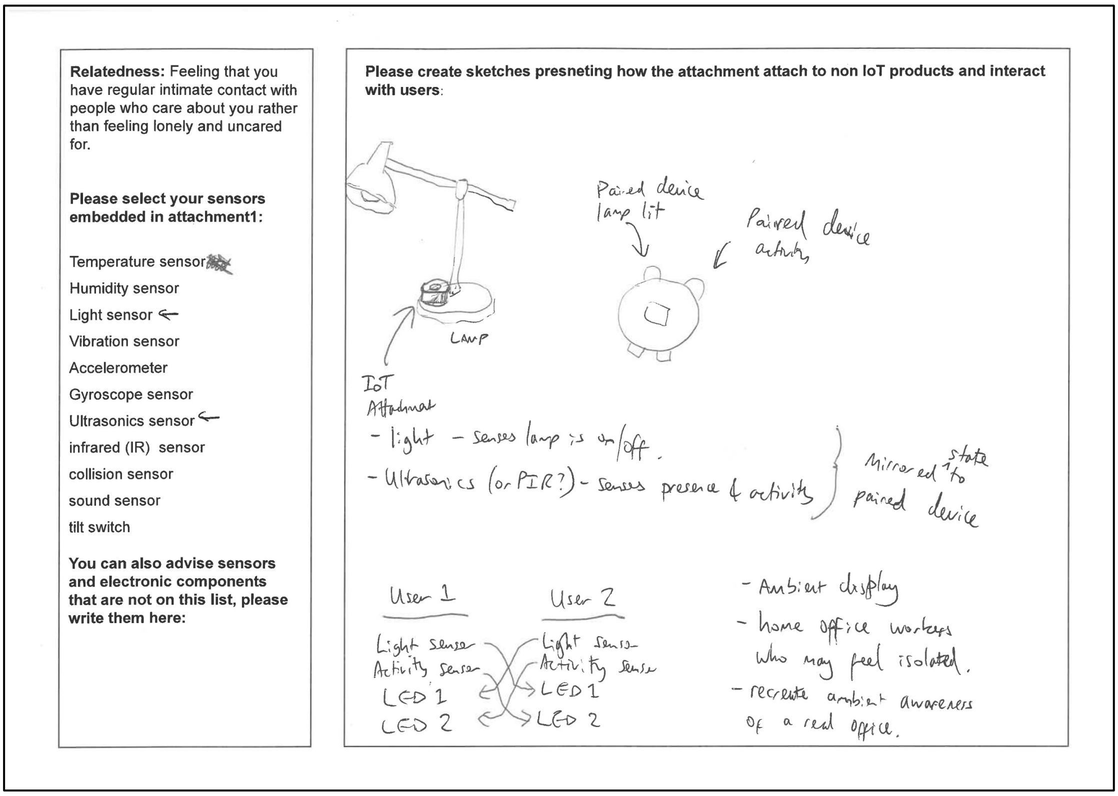
The text under the image represents the participants' own interpretations of their ideas transcribed by Otter.ai. Transcriptions were lightly edited to maintain anonymity, correct minor grammatical errors, and complete incomplete sentences only where the intended meaning was clear. All edits were made to improve readability while preserving the original spoken style and meaning.

## Design Activity 1

### My idea

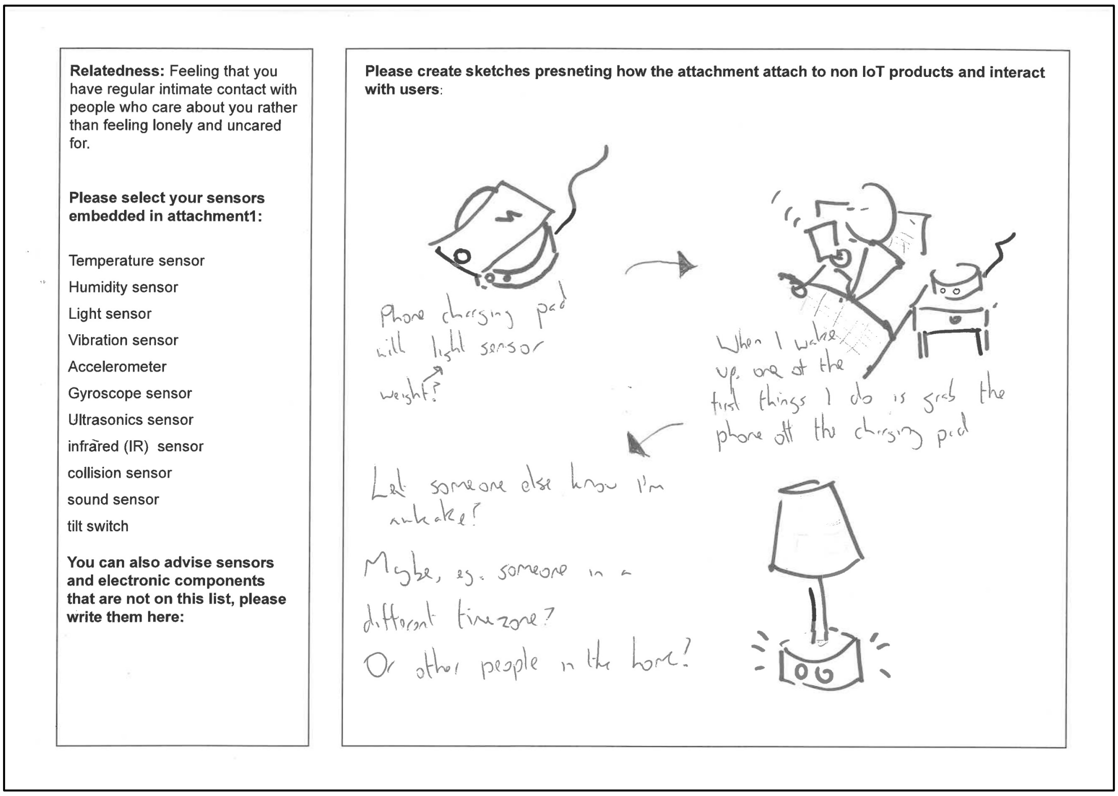


**P1**



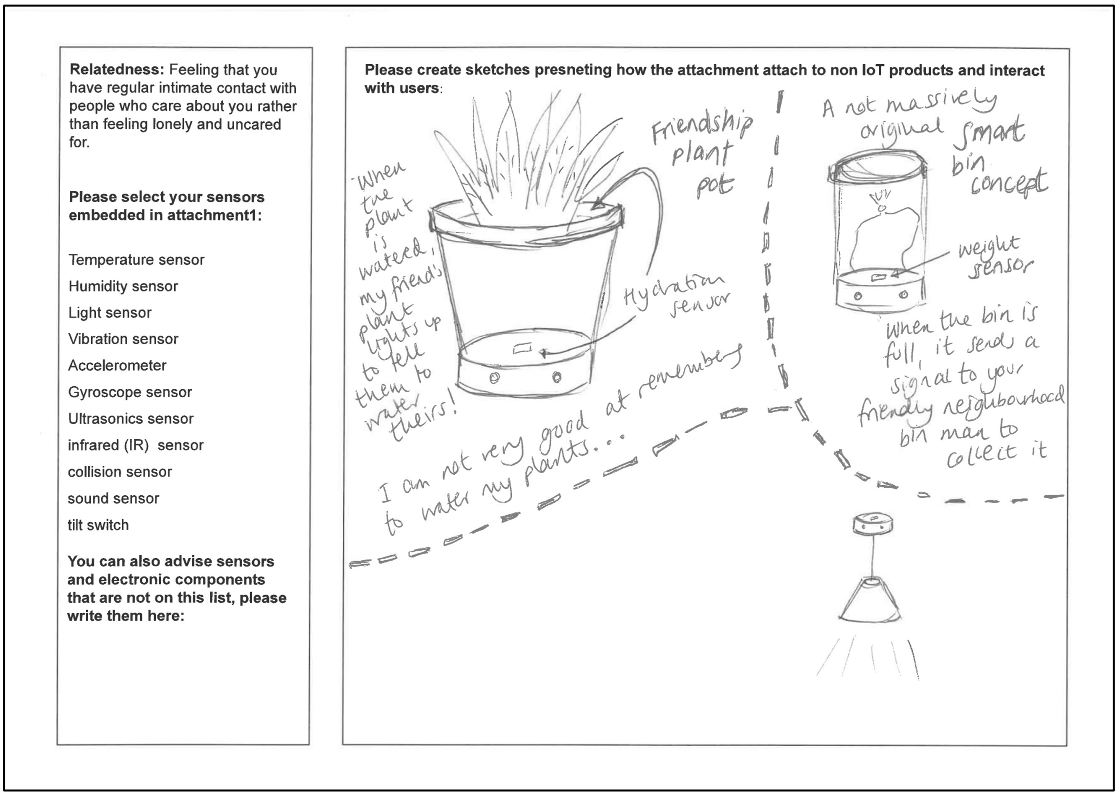

So my idea was that it's aimed at people who work at home. So, home office workers. You may feel isolated during the day if you're working, perhaps, by yourself for a lot of the day. And it gets them back in touch with maybe another co-worker who might also be working at home, so that they have some ambient awareness of what they're doing, when they're working, and so on. So I think it's trying to recreate some of what you might get in a real office. So, perhaps, if someone's working late and you could see a lamp or a light was on in their office room from a distance, you might be thinking that they could still be there. Or you might see signs of motion and activity that might indicate when they're there and when they're not there. So the idea was that you could just attach the device to the lamp. It could detect light levels, which would say whether the light was on or not, to give that awareness of whether this other person's lamp was on, and then use something to detect presence. So, perhaps ultrasonics on this list, or perhaps a PIR sensor that isn't on this list, might be useful to know when someone's moving around. And so both of those signals could be presented on the LEDs. And it would just give you this sort of idea of when people are working, perhaps later on, and when they're present or not present. And it might let you then contact them, and have some awareness that they've been away or that they've just returned home.

**P2**



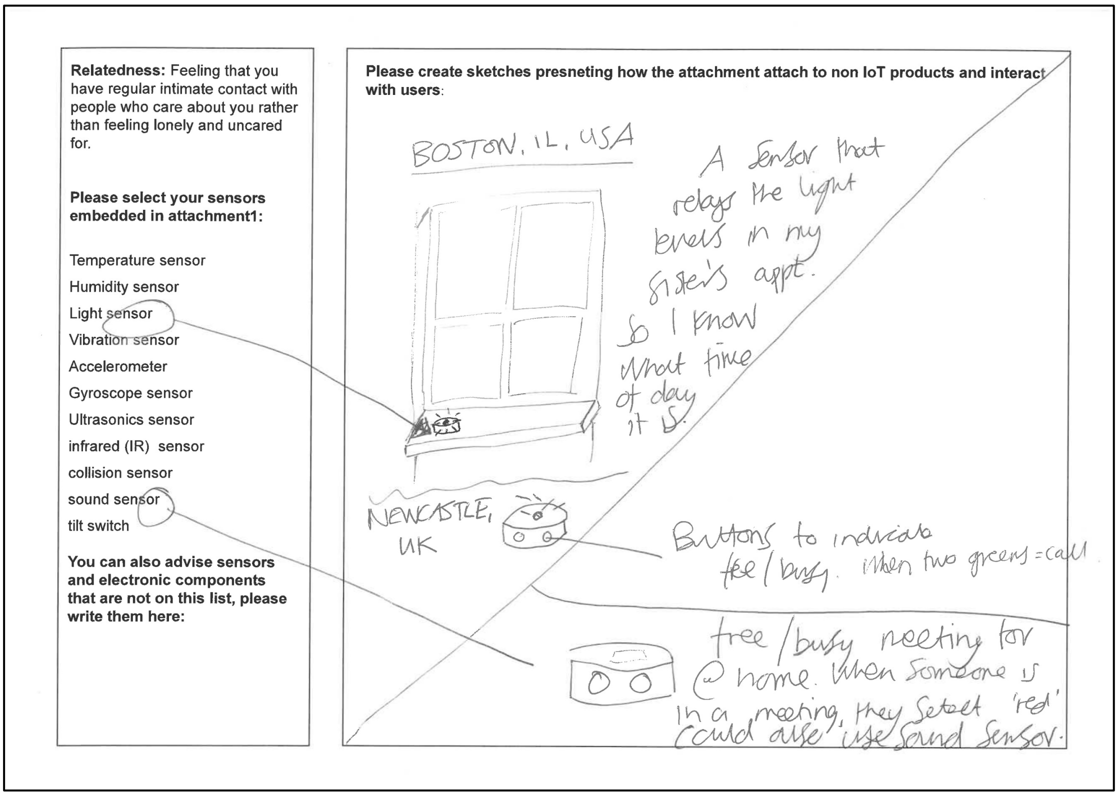

So, that kind of puck shape made me think of a wireless charging pad for your phone. One of the first things I probably do when I wake up in the morning is grab my phone off the wireless charging pad. So it's kind of interesting, because then you sort of know when somebody's woken up or when they're conscious and ready to interact with the world. I was thinking it might be nice to know when somebody else has woken up. Say, if your partner was somewhere else, especially if they were travelling in a different time zone, it's always interesting to know when they're awake. You don't necessarily have to think, "What time is it in America?" or "What time is it wherever they are?" You just have that awareness that they're awake now, and then you can talk to them or send a message or something like that. At the other end, it could also be a charging pad, but equally it could be a lamp or something else. The two ends don't necessarily have to be the same object, like your teacup and teapot, they don't need to match. It could be something else at the other end that's inviting someone to talk. I also thought it might be interesting in a family home context. You don't always know other people's routines or when they're awake. Sometimes you're listening to tell if people are moving around yet or not. So I thought it might be interesting in that context as well. It could even give you a voice update, maybe using some sort of phone connection, but with a sense of who else is awake and ready to interact.

**P3**



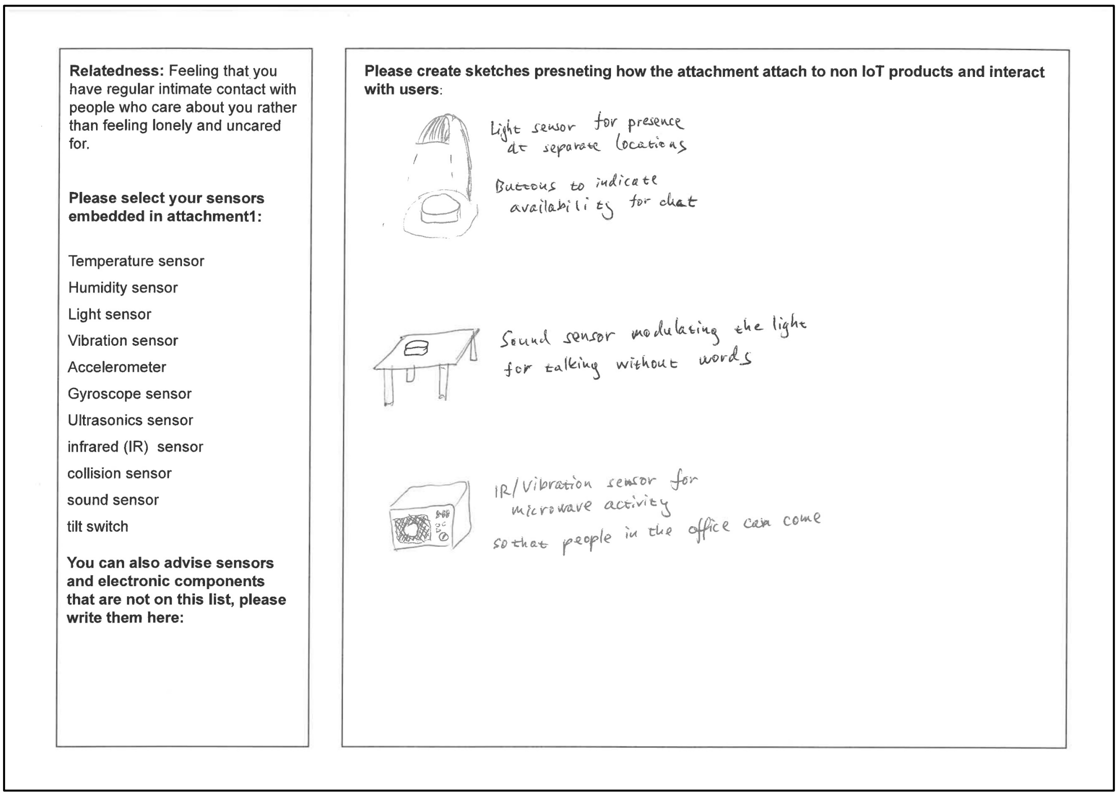

I think I struggle to think of things that are the right shape and that connect to people. So I think my favourite of my not-brilliant ideas is that there could be four plants, so you can have it attached to plant pots. Basically, someone else could remind me when I need to water my plants, because I’m so bad at it. So, when my plant friend, who is very good at plants, waters their plants, then I would water mine. That way I’d also remember to water my plants, which would be a helpful thing for me. It might be a gift you give with a plant to a friend, to be like, “Yeah, I’m going to look after mine if you look after yours.”

**P4**



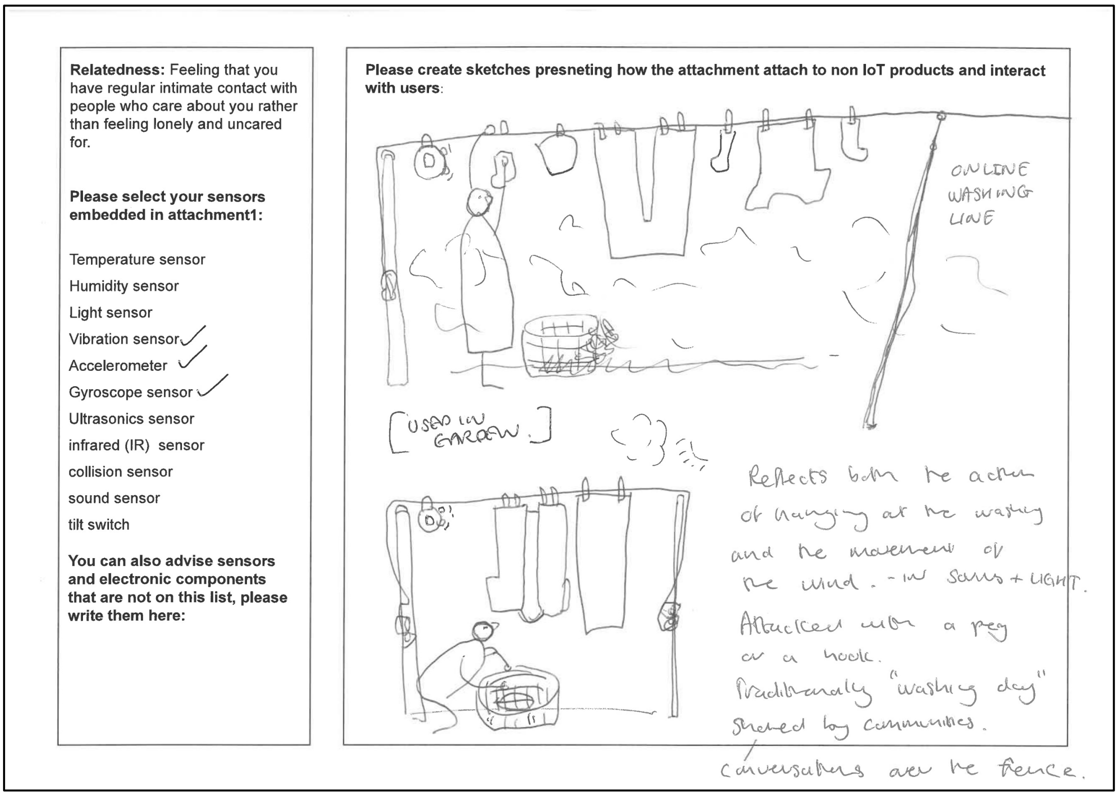

I did two ideas. One was inspired by yours and P2's. It's a sensor idea. My sister lives in Boston in America, and I was getting really confused with the time difference, whether it's behind or ahead. So I thought she could put the device in her apartment that would detect light levels. It would then indicate to me when it was light in her apartment, which might suggest she was available to be contacted. I thought we could also use buttons. She could press to say that it's not a good time to talk, or that it is a good time to talk, and I could do the same. If both people pressed the green buttons, it would light up, and it would be like we're both wanting to talk to each other. I'd have the corresponding device in the UK. Although I don't think she ever really struggles with time difference, she's never asked me at, say, 5 a.m., I think it could still be a useful reminder. The second idea is probably simpler. I'd want my partner to have a device on her desk that she could use to indicate whether she's in a meeting or not. Quite often I'm downstairs, shouting up to my partner to ask if she wants a drink or something like that. And obviously she doesn't answer because she's in a meeting, but I don't know that until later. So I thought some kind of "free/busy" indicator might be useful. It could use buttons, but it could also use sensors, for example, to detect if there's sound coming from the room. And maybe, when you press the opposite status, it could also indicate other activities, like if people are going around the house and cleaning up.

**P5**



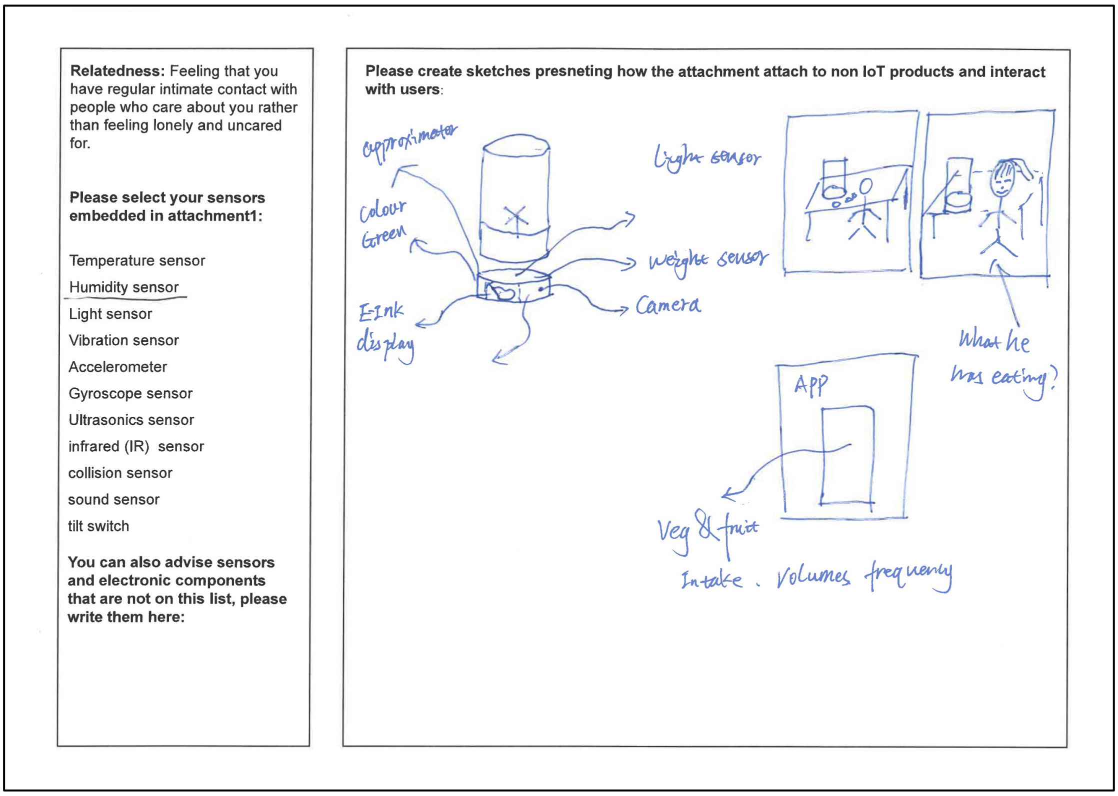

Yeah, I know mine personally was like many of yours, which is that a light sensor for the presence of people is interesting, because I have done some work with remote couples in the past. It’s nice to see that this still seems to open up possibilities for people to sense each other’s presence. I know it’s an important moment when Brandon comes home at night, and you don’t want to be constantly asking where they are. In my case, the labels on the buttons were meant to indicate the availability of people to chat together. The idea I had was sort of similar to your kettle idea, but it was a microwave. I like that because, for tea, you kind of expect it to be a communal experience, while with heating up food for yourself you don’t have that same expectation to share. People might just start eating, but you still get those little moments where others come by. The last one I had was also similar to using a sound sensor in an environment. My more ambitious usage was to use the sound to modulate the light on the other side, so you could communicate without words. You could make sounds, and that would light the bulb, and the beacons would communicate with each other.

**P6**




I'm thinking about traditional terraced houses where there's a routine for washing day. So essentially, it starts off with the idea of an online washing line. You hang things on the washing line and, as you're pegging out your socks and everything, the movement comes partly from you doing that and partly from the wind. There's another one as well. It's essentially getting back to the idea of washing day. It's a bit contrary in a way, but I think it's interesting. Having it in the garden is interesting, and it ties in with the physical practice of washing and cleaning.

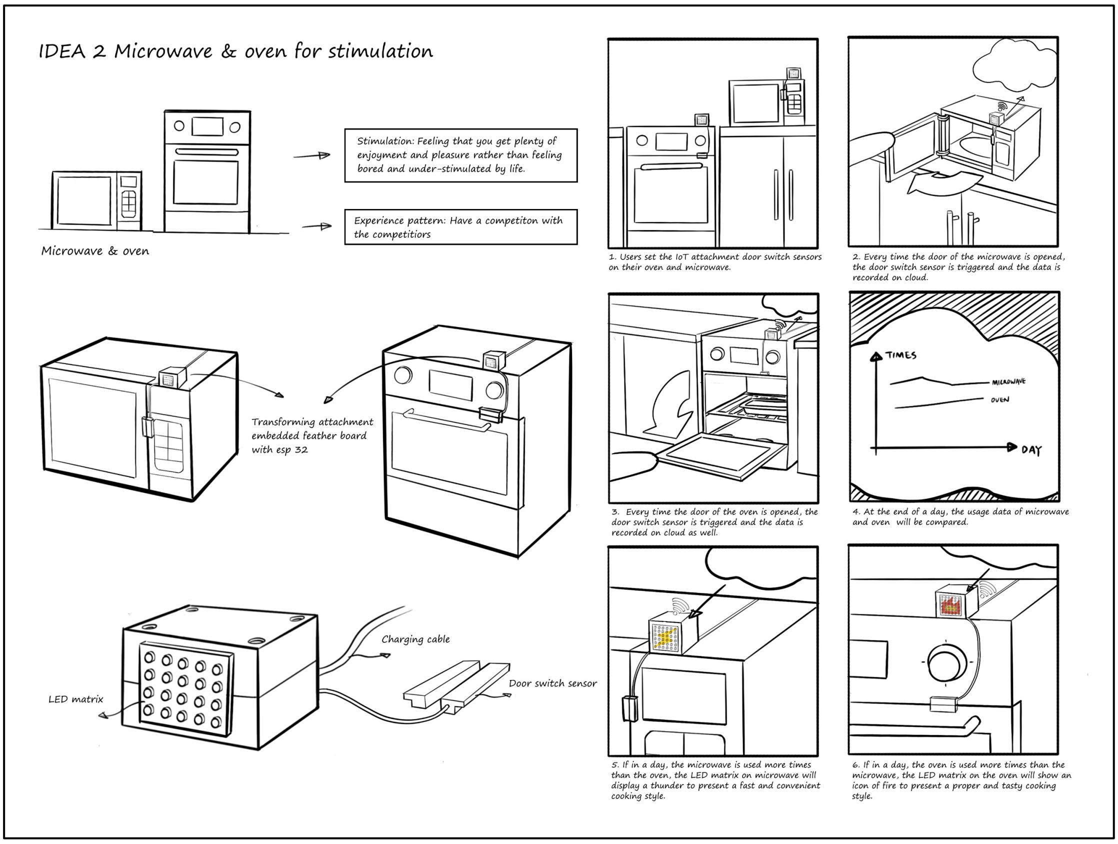
**P7**



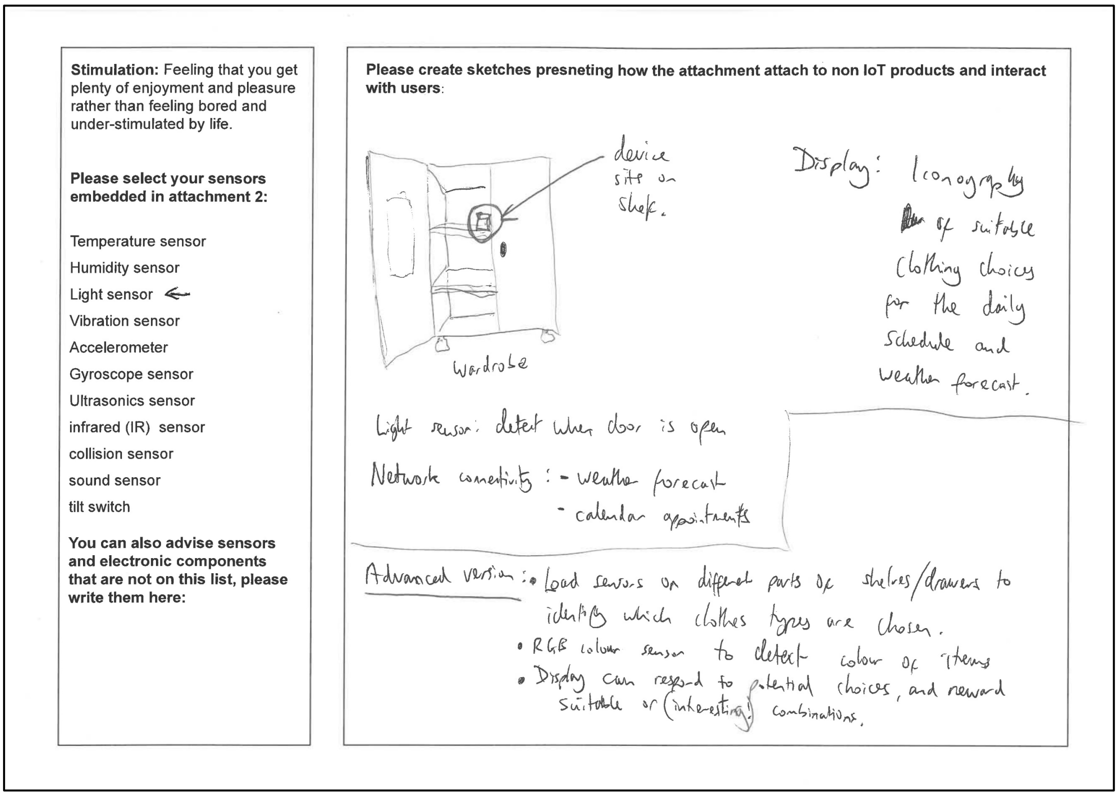

Mine was pretty traditional, like most IoT products created in that category. So this one is for sensing what I eat in the kitchen. Basically, I pick it up, and… well, you could put fruit into it — it's a blender. The idea is that it's better for people who want to precisely control when they eat and track calories. It's a good time to record it. The app could scan or take photos of what you're making. So, basically, this is the base for the blender. It could have a camera so you can look from certain angles and see all the fruits or vegetables on the chopping board. It could also have a weight sensor to know how much I put into the blender. A tiny display could show what I've eaten, and it could have LED multicolour indicators to approximate when I'm at home. My wife could use this, for example, to get notifications about what I've been eating, especially because she organises all the groceries online. She doesn't always know the day-by-day consumption, so it would help her plan the next delivery. All this information could be sent to an app, where you could check all the details. The main point is that even if some information is missing, it's still better than missing everything. That's what I thought.

# Design Activity 2

## My idea

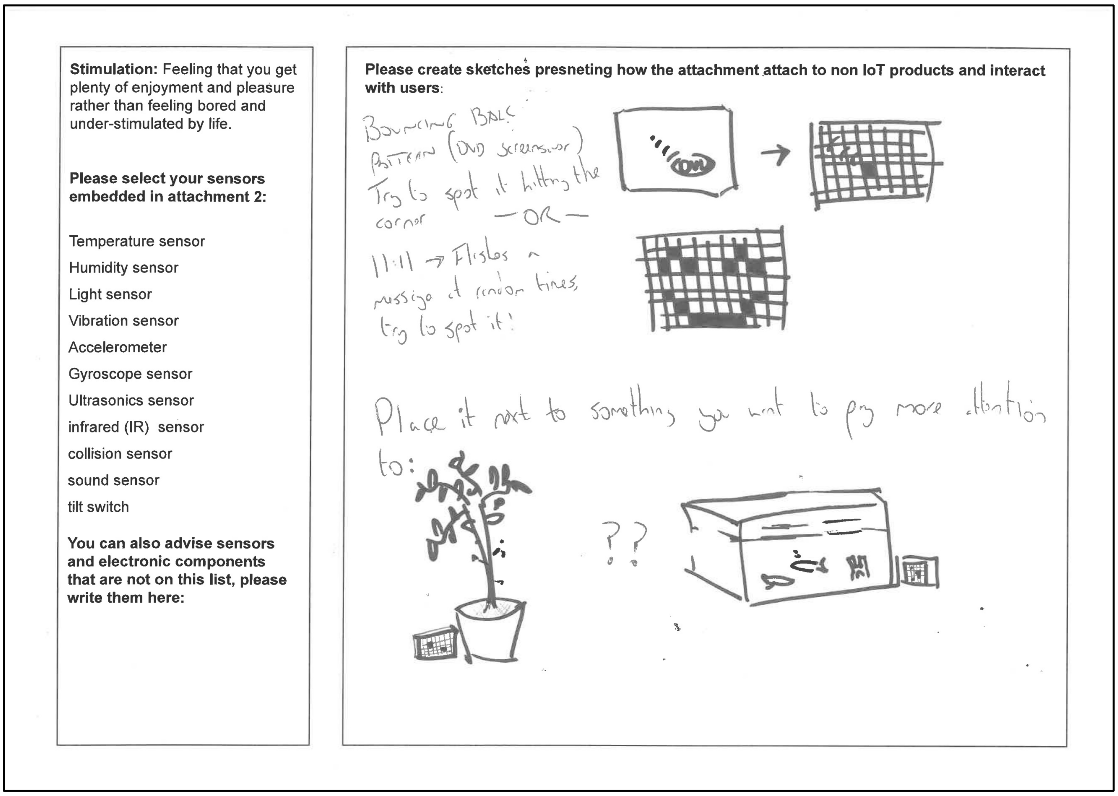


**P1**



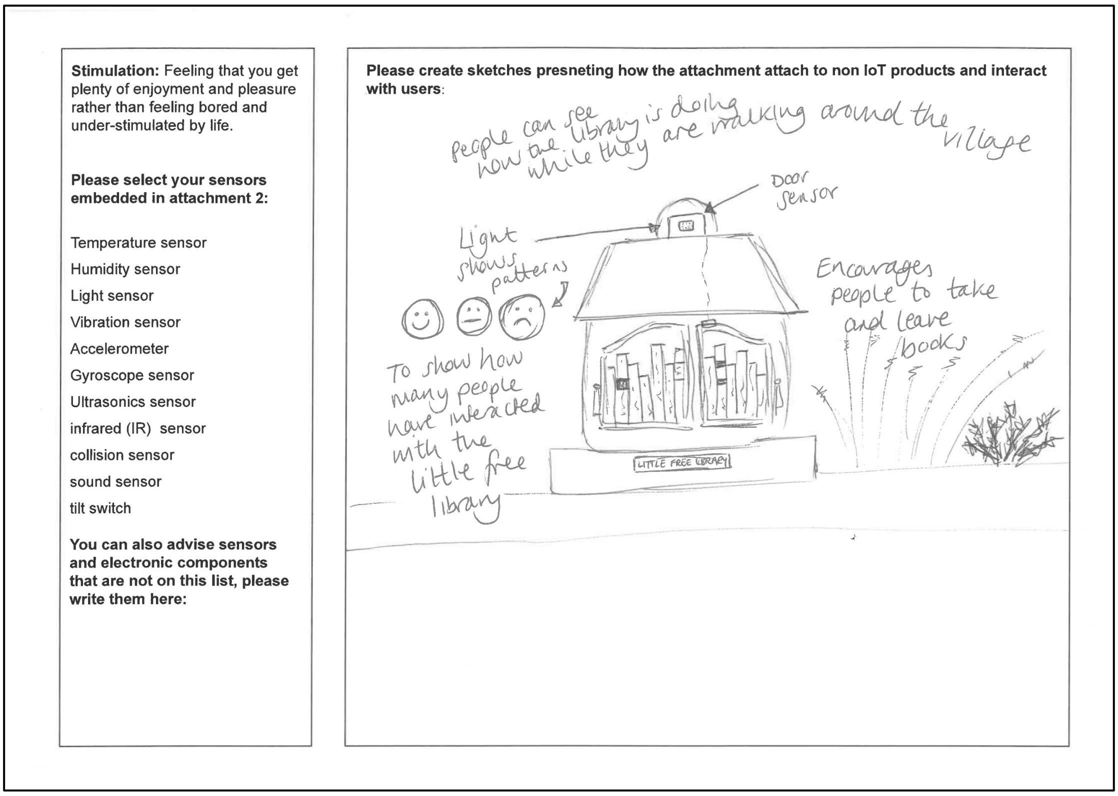

Okay, so my device is a little thing that just sits on a shelf in a wardrobe. Initially, it provides a useful function, which is to remind me what would be a suitable type of clothing for the day. For example, whether it's going to be warm or cold, or whether it's going to rain. If it's internet-connected, it could look at the weather forecast and also check your calendar to see when you might be outside versus inside, so you know when to care about the weather. I find that function useful or entertaining, perhaps. But to make it a bit more entertaining, if you had additional sensors like load sensors on the shelves, it could tell what type of item you are picking out. Then, if it had an RGB colour sensor, you could hold the clothing up to it, and it could express its approval or disapproval of your colour choice. This could be based on whether the combination of clothing coordinates well or looks interesting, or perhaps if you've become too boring and you're choosing the same items every day. It could try to encourage you to be more adventurous with your choices. So it's sort of like a wardrobe-based valet.

**P2**



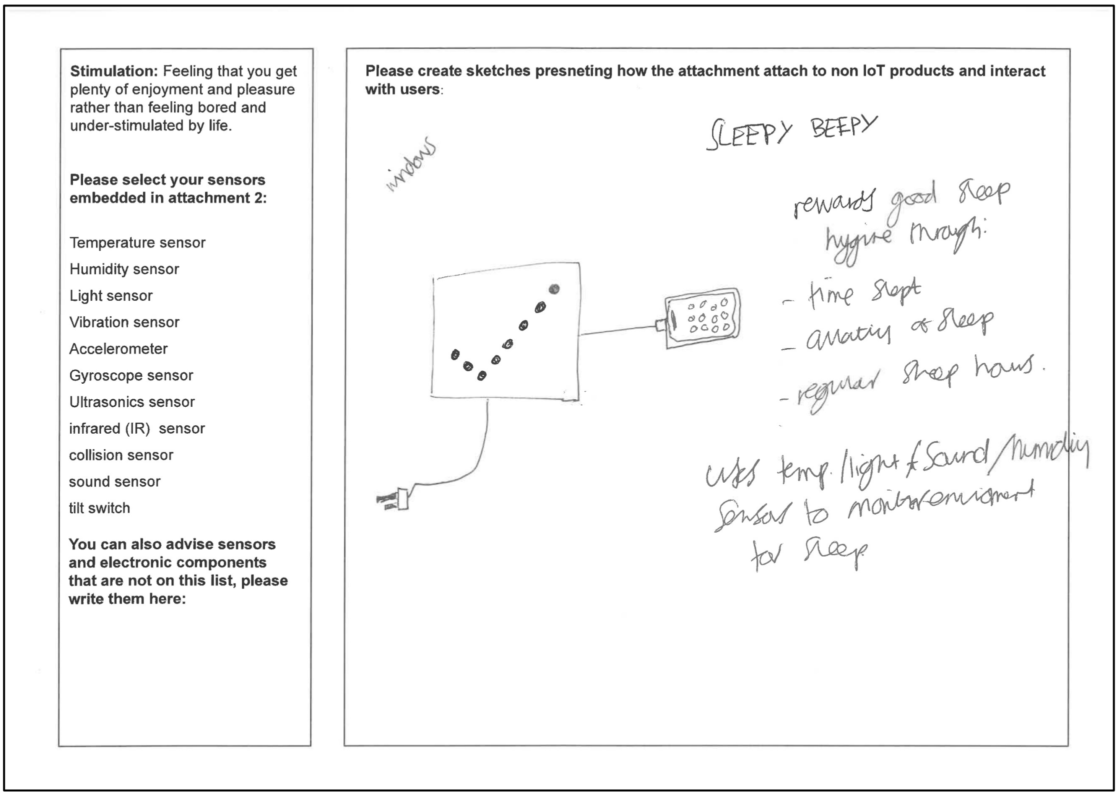

This is a bit half-formed, or maybe even just a quarter-formed idea. I was thinking about what you could do with a matrix-style display, which I thought was quite cool. For some reason, I was reminded of how DVD players used to have that screensaver with the little DVD logo bouncing around. People would play a sort of game, getting excited when it hit the corner of the screen. I thought you could have something like that, a ball bouncing around, where people might play the same game on a new kind of display. I also remembered hearing about people who are convinced that every time they look at the clock, it says 11:11. So you could have a special pattern or image that flashes occasionally, and you have to try and spot it. Both of these ideas are about making you pay attention to something, paying more attention to something you might otherwise ignore. It's about making something boring more fun so you engage with it more. I struggled to think of what that "something" might be, but maybe it could be a plant, something you have to care for, though I'm really bad at that, so it could draw your attention to the plant. Or maybe it could be an aquarium, reminding you to feed your fish. So maybe this is only a third-formed idea.

**P3**




Yeah, so I designed quite a specific thing for my idea. I have a little free library at my house, which is like a community book-sharing point. This is actually a drawing of a secret library in my garden. I've purchased a device for the top, which is a perspex dome mounted on what used to be a refurbished fireplace. It links to a door sensor, so you can tell how many people have interacted with the library. The device would then display a red sad face, an orange medium face, or a green happy face, depending on how many people had interacted with it and taken books. The idea is that it would show how "happy" the library was, based on activity, and hopefully encourage people to take more books. This would add to their feelings of enjoyment, help relieve boredom, and hopefully be a nice thing to encounter when walking around the village. It might also encourage more people to walk. I have also tried to work on plants before… not very successfully.

**P4**


**Stimulation:** Feeling that you get plenty of enjoyment and pleasure rather than feeling bored and under-stimulated by life.

**Please select your sensors embedded in attachment 2:**

Temperature sensor
Humidity sensor
Light sensor
Vibration sensor
Accelerometer
Gyroscope sensor
Ultrasonics sensor
infrared (IR) sensor
collision sensor
sound sensor
tilt switch

**You can also advise sensors and electronic components that are not on this list, please write them here:**

**Please create sketches presneting how the attachment attach to non IoT products and interact with users:**



Mine's called Sleepy Beepy. It's kind of borrowed the idea of plugging in your phone, like you mentioned earlier, and it tries to optimise your sleep. I don't usually get enough sleep or keep regular hours, so the idea is that it would score you on whether you're going to bed at the same time each night and getting up at the same time each morning, or how much sleep you're getting overall. It could have sensors, maybe motion sensors, depending on what you think is useful. It could also look at temperature and sound levels as a way to suggest how you might make your environment more conducive to sleep. And it beeps, because it would be much better if you actually listened to it.

**P5**

**Stimulation:** Feeling that you get plenty of enjoyment and pleasure rather than feeling bored and under-stimulated by life.

**Please select your sensors embedded in attachment 2:**

Temperature sensor
Humidity sensor
Light sensor
Vibration sensor
Accelerometer
Gyroscope sensor
Ultrasonics sensor
infrared (IR) sensor
collision sensor
sound sensor
tilt switch

**You can also advise sensors and electronic components that are not on this list, please write them here:**

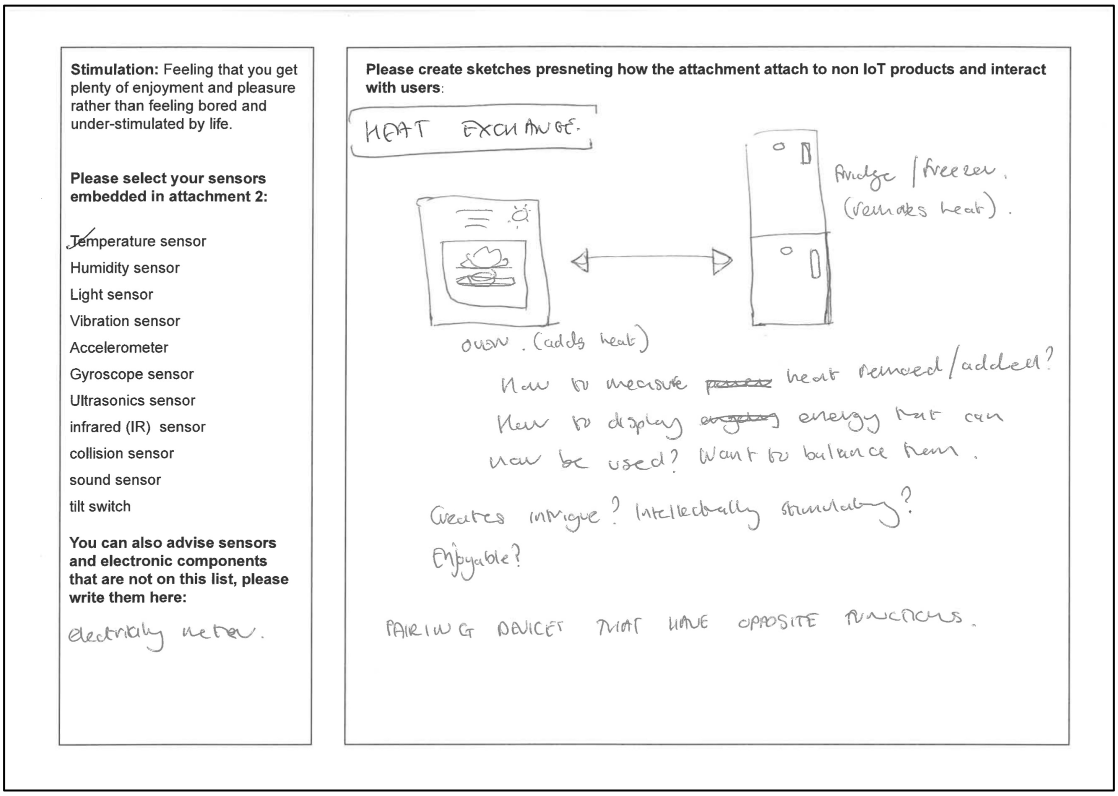
**Please create sketches presneting how the attachment attach to non IoT products and interact with users:**

Accelerometer+Gyro, particles on display, movement shakes them and creates patterns - could be placed on washing machine or other moving things

Collision - smash table to generate new QR that would open quotes or pictures

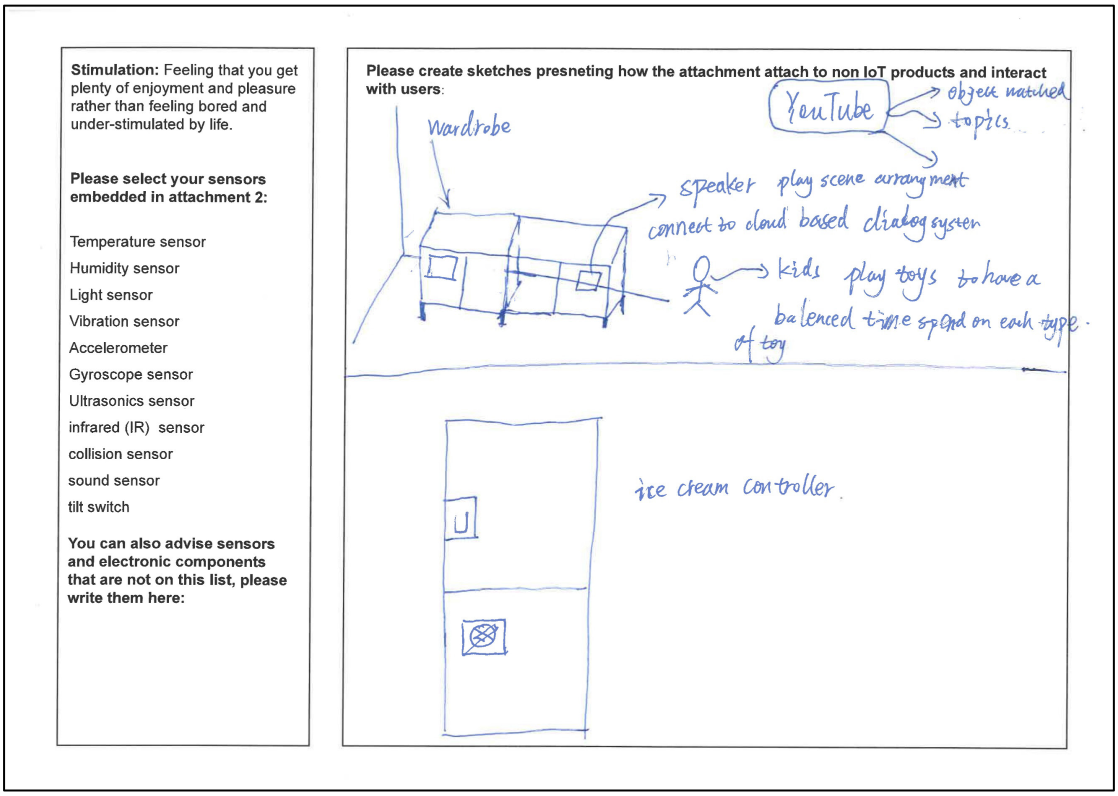
Alright, so my idea… I've been using them in a graphical way. One concept is something like an hourglass display. The display shows particles of sand, and as you shake it, the particles rearrange into some preset shapes or designs. You could, for example, put it on a washing machine and have it generate nice patterns while it's running. The other idea is a collision detector. The idea is that you put it on a table, and when you bang on the table, it would show something like a QR code. That QR code could then lead to something like comic books, pictures, or other content.

**P6**




I quite liked the connection between the cooker and the microwave, and then I started thinking about other possibilities. I began looking for things that were sort of opposite to each other, like they had some opposite function. That made me think about the fridge freezer and the cooker. My idea is called Heat Exchange. I’m not exactly sure how it would work, but the sense is that the heat you take out of things in your fridge or freezer could be used in your oven, or vice versa. I’m not entirely convinced it’s fun, but I think it would be intriguing, at least. Maybe there could be a scaling factor, so you don’t have to match it exactly. Maybe you could use twice as much heat for cooking as you get out of freezing food. But anyway, that’s Heat Exchange.

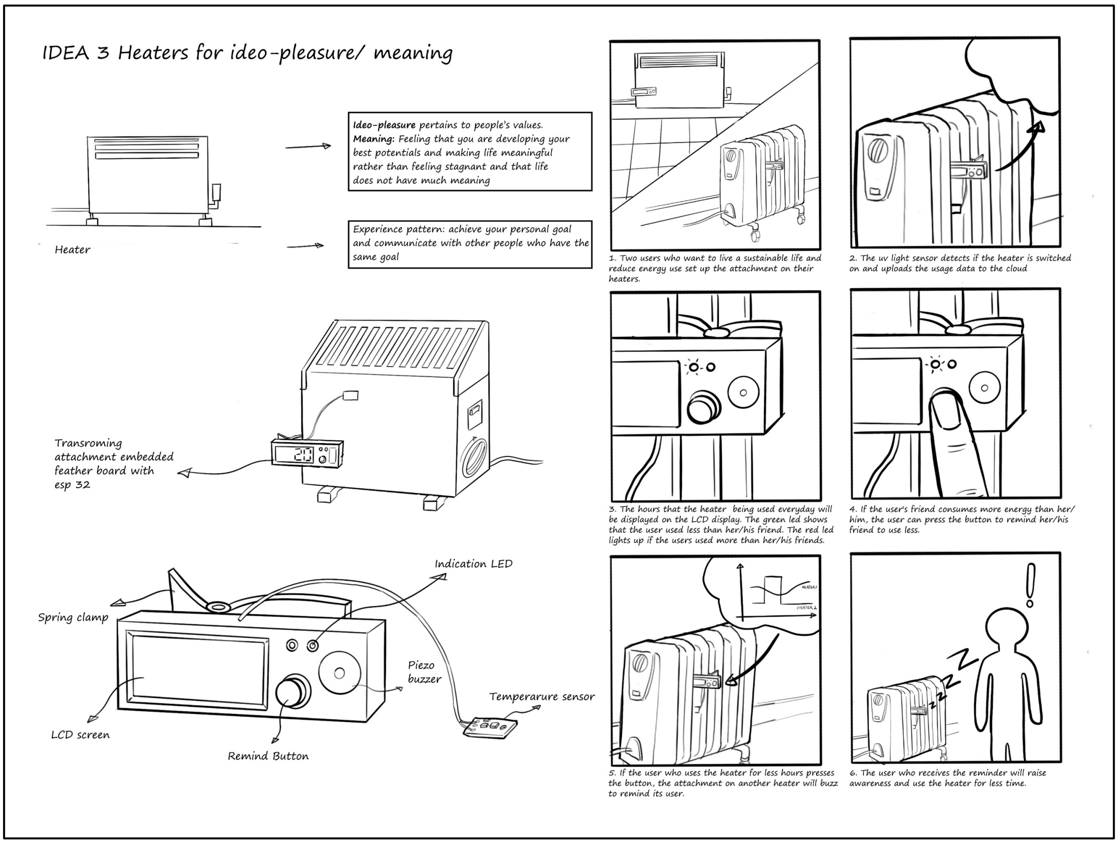
**P7**



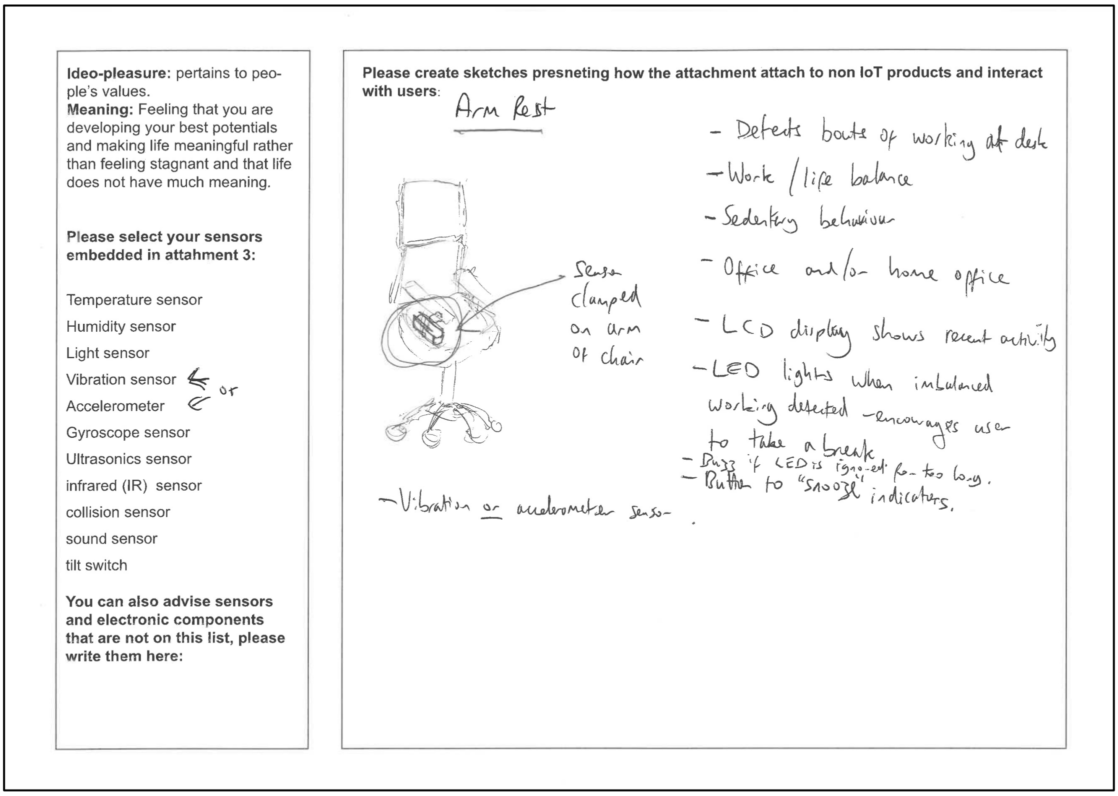

Alright, so I have designed two different scenarios. The first scenario is a storage box. For example, in our house we have a big box to store all the toys for my little one. He opens it, takes the toys out, and sometimes has trouble finding them again. I thought it would be nice to have something to help balance the time he spends on different types of toys, so he doesn't obsess over just one. We've spent money on different toys, so I'd like him to get a balanced experience. I started thinking about this because sometimes he watches YouTube videos. We know what he's watching, and sometimes we buy toys that match the videos, like themed playsets or things that encourage safety awareness or environmental awareness. So my idea is to have a colour display gadget attached to each box, so it knows which toys are in which box. Based on the content of the videos he watches, it could give him a prompt to play with certain toys. It would have a kind of "secret" element because I think in that case he wouldn't have an issue interacting with the device. When we start it, there's actually a person's voice or personality inside, so it wouldn't feel boring, and it could have a dialogue system. Occasionally, using Microsoft or Google's cloud, we could determine the logic so that, based on certain triggers, it could invite him to play with something. For example, sometimes after watching half an hour of TV, he'll start a conversation with me and grab me to play toys with him. That's fun, and the system could support that kind of interaction. Of course, there'd be a time limit, and after an hour it could remind him to stop playing and focus on physical exercise outside in the garden. The second scenario is called Ice Cream Controller. I often find my ice cream has disappeared for no reason. I ask my wife, she says she didn't take it. I ask my child, he says "I didn't take that." So I'd like something to track this. I presume it's him. When he opens the fridge, I'm not sure if this would work at minus 17 or minus 24 degrees, the system could count how many times he opens the dedicated ice cream drawer. When he does, it could display a little monster saying "Oh no, don't grab me!" The next time he might think twice. It could also be connected to the top compartment so we can see if he's taking yoghurts or other unhealthy things, and remind him to grab something better, or call me. There'd be a speaker too, so the kids wouldn't have to press buttons or use joysticks, it would mainly work through the dialogue system.

## Design Activity 3

### My idea

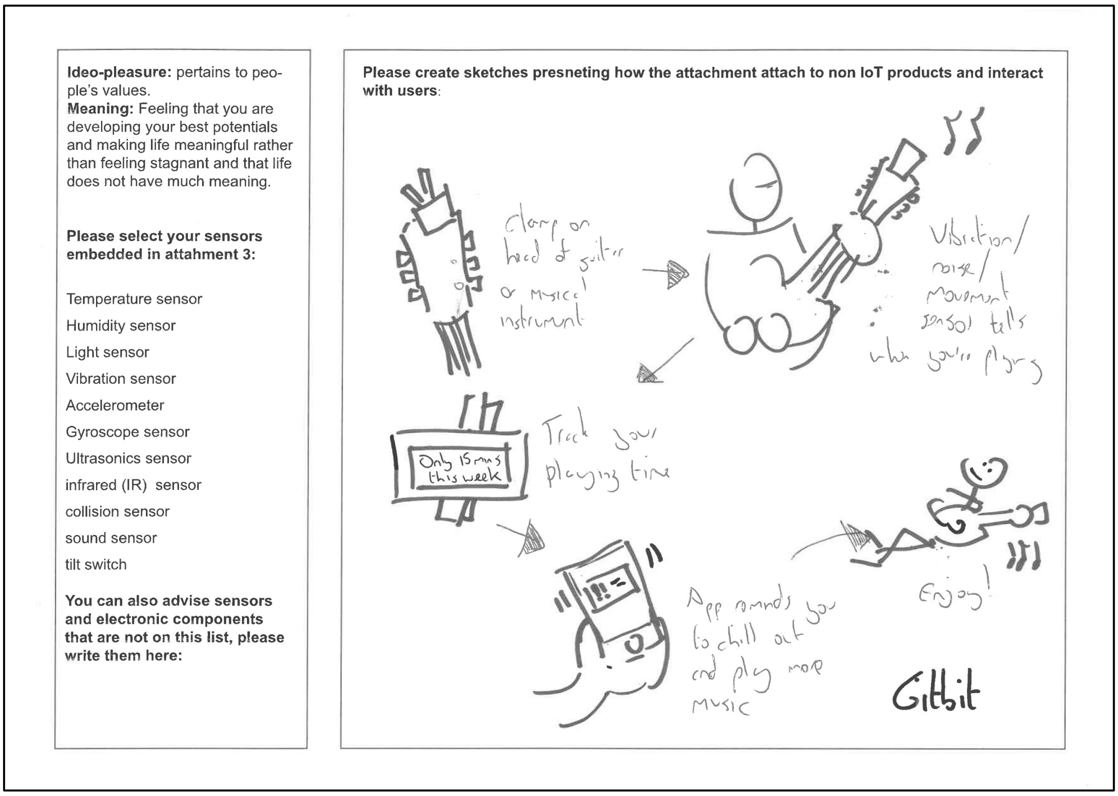



**P1**



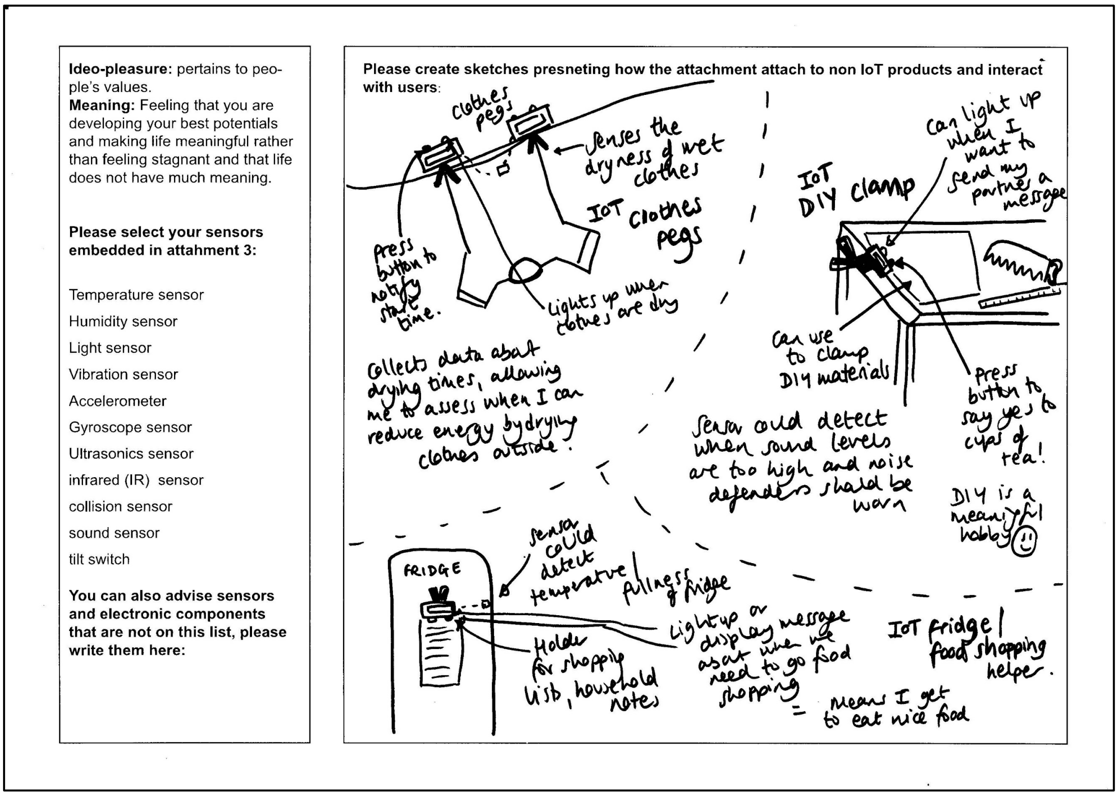

Mine is tentatively called On Rest. The idea is that you would attach this to the arm of your chair — I'm thinking about an office chair, probably more suitable for a home office environment, but it could work in any office. It would use a vibration sensor or accelerometer to detect when the chair was occupied. The concept is about work-life balance. People, especially when working from home, might sit for long periods without other stimulation and without taking breaks. They might not go for a walk or step away from work. The device would track accumulated sitting time and the length of uninterrupted working periods. The details could be shown on a display so you could glance at it. An LED indicator could warn you when it might be a good time to take a lunch break. If that gets ignored, the device could buzz to annoy you into taking a break, with a button to snooze the alert in case you're doing something that can't be interrupted. The goal would be to help maintain a healthy work-life balance. I think the simplest version would work best if the chair was exclusively used for work. If the chair was used for other activities, it might be harder to get accurate data, so you might need a software element, maybe on the computer, to identify when you're actually working.

**P2**




The shape of this clamp kind of reminded me of a clip-on guitar tuner I used to have, about a quarter of the size but a similar kind of clip-on design. I thought about something that could be clipped onto a musical instrument, like the top of a guitar, and track playing by sensing sound, vibration, or movement. It would track how long you've spent playing your guitar, kind of like a Fitbit for musical instruments, and I'd call it Guitbit. In the same way a Fitbit detects your activity and suggests you do more exercise when you haven't hit your targets, a lot of quantified-self devices are about doing more. But I like the idea of turning that push on its head. Instead of telling you to do more work or more activity, it could ping you a message like, "You haven't played your guitar much this week — why not just chill out and play for a bit?" It would be something that encourages you to slow down and enjoy life.

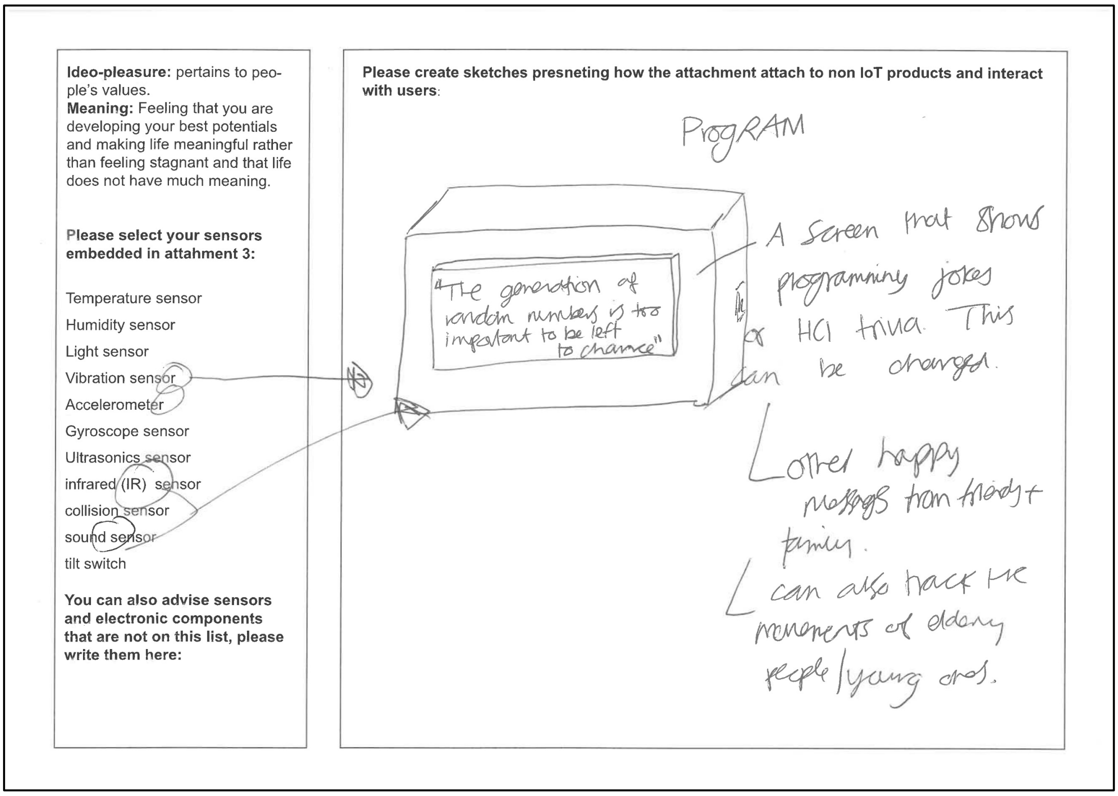
**P3**




So I came up with three ideas, which I attempted to draw badly. My first one was the idea of using this as a cloth peg. I decided it would have a sensor to detect how dry the clothes were, and I could press a button to note the start time when I put the clothes out. It would then light up when the clothes were dry. This would allow me to collect data about drying times and give me an idea of when I could use the washing line rather than the tumble dryer and save energy. I thought I could collect some interesting data about how long drying would take, and connect it with the temperature outside. I could think, "Yes, I can dry stuff today in three hours," or, "No, I can't dry it outside today." My second idea was designed for my partner, and it started with a DIY-style clamp. I thought it could be used for DIY materials. The screen and light could be used when I want to send my partner a message while he's doing his DIY hobby. He could press a button to say that he wants a cup of tea if I messaged him about it. The sensor could detect sound levels, so if he was drilling or hammering, times when he needs to be wearing ear defenders, the device could respond appropriately. I struggled with the sensor element of this idea, but I designed it for him because he finds DIY a meaningful hobby. My third and last idea was for the fridge. This device would stick on the fridge door and maybe hold a shopping list. The sensor could be attached to the fridge to detect, at first I thought, temperature, but then maybe the fullness of the fridge — how much food is in there. It could light up or display a message when I need to go food shopping, because I frequently forget.

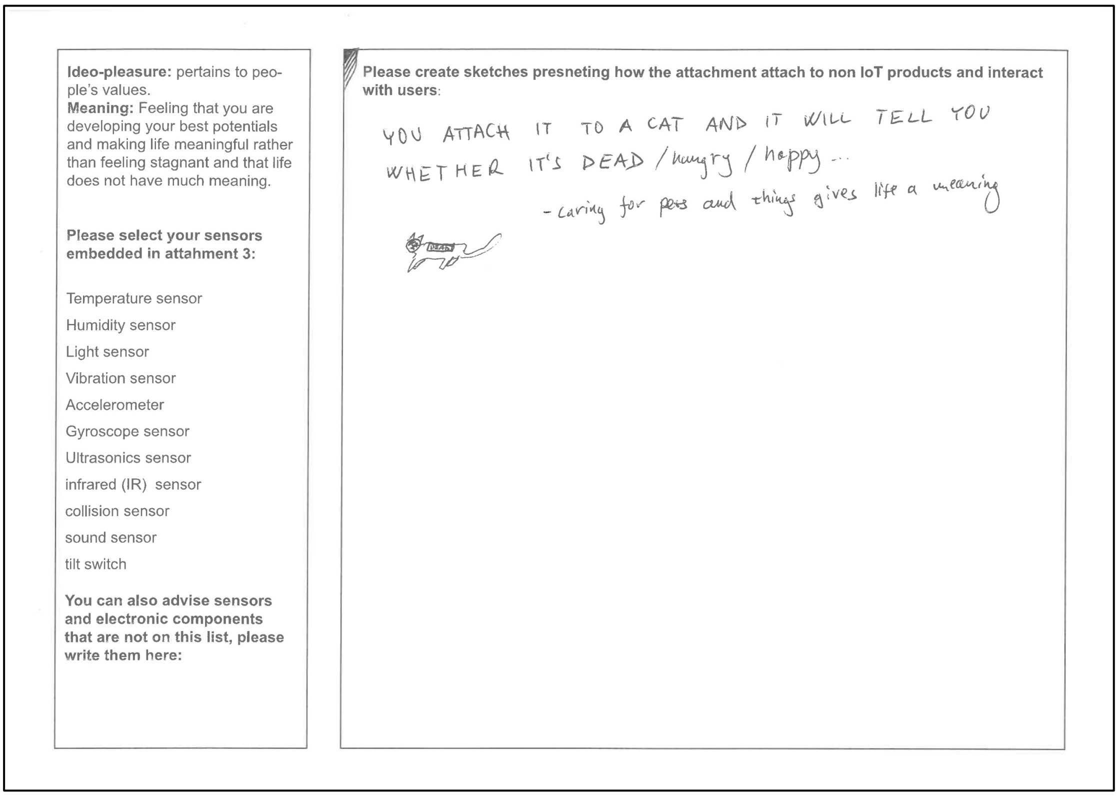
That way, I'd get to eat nice food rather than just whatever happens to be left over.

**P4**




It's a bit dark, and not really a serious suggestion. It's basically a thing you give to your parents or to an older person. It shows a variety of things — for example, in this case it shows programming jokes, like "The generation of random numbers is too important to be left to chance." It could also display HCI trivia. But secretly, it's got a presence sensor and can track the movements of elderly people. That way, you could keep an eye on them, but they would just think it's a harmless, entertaining device.

**P5**



Ideo-pleasure: pertains to people's values.
Meaning: Feeling that you are developing your best potentials and making life meaningful rather than feeling stagnant and that life does not have much meaning.

Please select your sensors embedded in attahment 3:

Temperature sensor
Humidity sensor
Light sensor
Vibration sensor
Accelerometer
Gyroscope sensor
Ultrasonics sensor
infrared (IR) sensor
collision sensor
sound sensor
tilt switch

You can also advise sensors and electronic components that are not on this list, please write them here:

Please create sketches presneting how the attachment attach to non IoT products and interact with users:

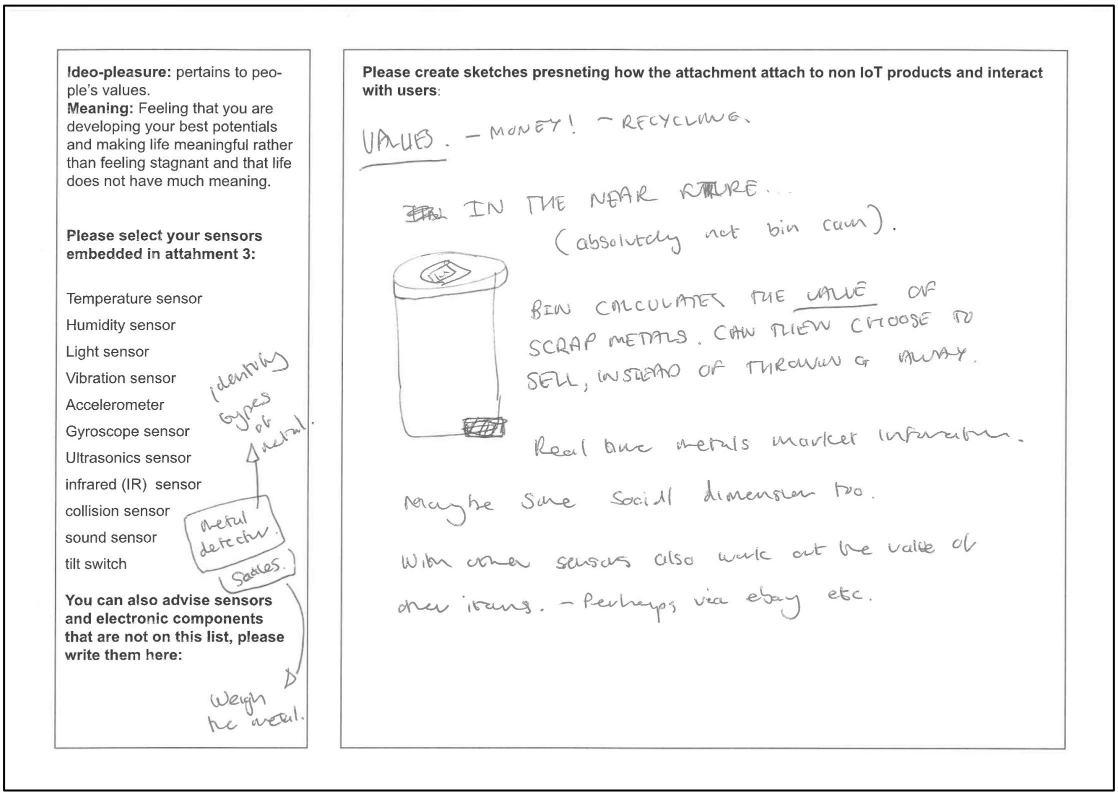
YOU ATTACH IT TO A CAT AND IT WILL TELL YOU WHETHER IT'S DEAD / hungry / happy ...
- caring for pets and things gives life a meaning

Basically, my idea is to attach it to a cat. It will tell you whether it's dead, hungry, or something else like that. The idea is that it's about caring for pets.

P1's Question:

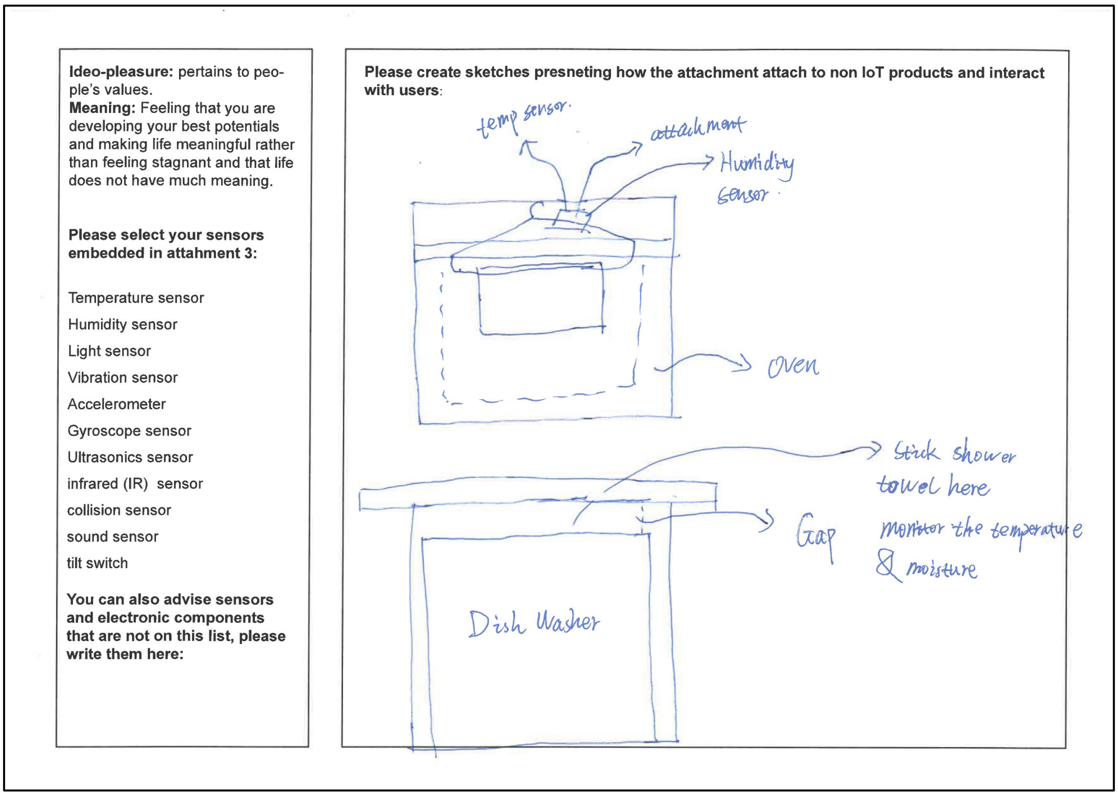
Did you try this clamp? I think it's going to be a very cursed cat put that already.

**P6**



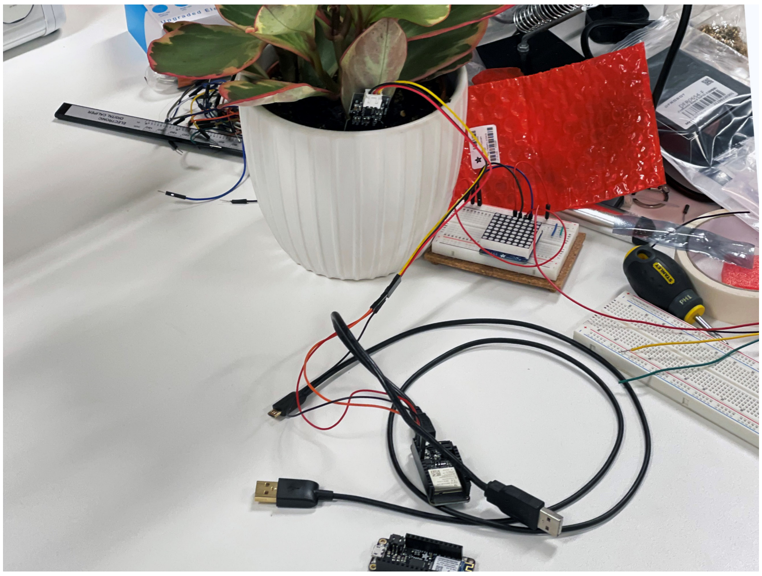

It doesn't have a name this time. I was thinking about values, and I thought about money as a value, but also about recycling and the environment. So this is a rubbish bin, and it's not "smart" in any surveillance sense whatsoever, unlike a previous project here. There are no cameras in it. What it has is a metal detector and possibly some scales. The idea is to persuade you that you might sell whatever you're about to put in the bin, rather than just throwing it away. For example, it might detect scrap metal and tell you the value of your coke can. This might be in a slightly near future where maybe a coke can gets you a small payment. A more advanced version could be something like a portal to eBay, so it becomes a way of thinking about how you dispose of things from your home, showing you their potential value. It could also have a social dimension. Again, there are absolutely no cameras, just a metal detector that could tell you if something is aluminium or steel, and scales to measure how much of it there is. That would be the minimal viable product.

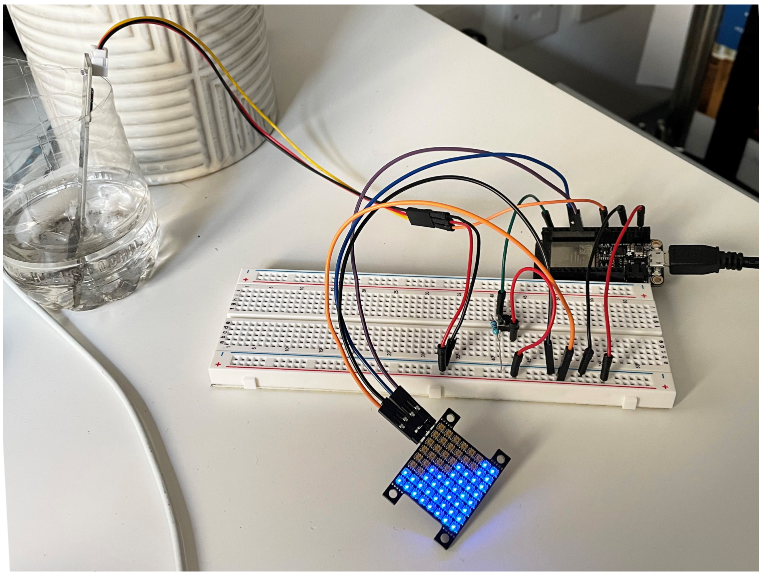
**P7**

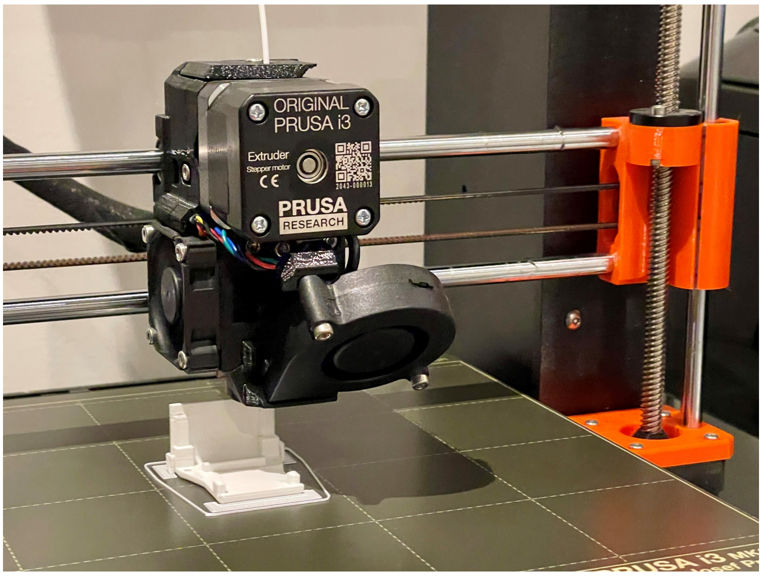


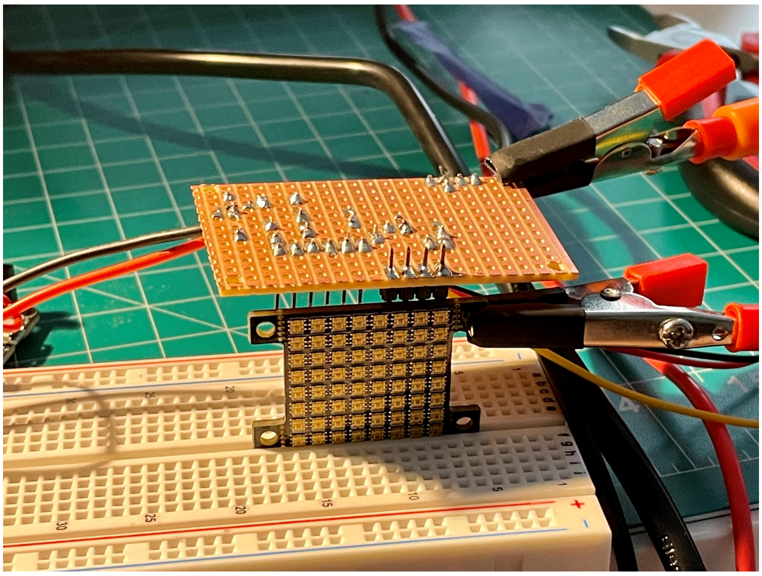

Activity 3 is a bit of a challenge. I think it’s more ideological and really broad. I don’t think I can save energy from cooling stuff, but I’d like to see how I could harvest energy from my freezers. That part borrows from P6’s idea, because my recommendation would be to have a humidity sensor so I can detect whether my towel is dry or not. I have an oven, and when I turn it off after baking something, it cools itself by blowing hot air out — not from inside, but from the case. So I don’t smell the inside. That creates hot air going up, which probably lasts for about 20 minutes. I was wondering whether I could hang my shower towel in front of it so it dries, rather than using the towel heater. There are other ideas, maybe less boring. Dishwashers sometimes have a gap between the dishwasher and the worktop. I actually put my bamboo-made chopsticks there, because after washing they can get mouldy sometimes. If I stick them in that gap, they dry up every day. So I thought I could also use that little gap to dry a towel or socks or things like that, but I haven’t found a better use for it yet.

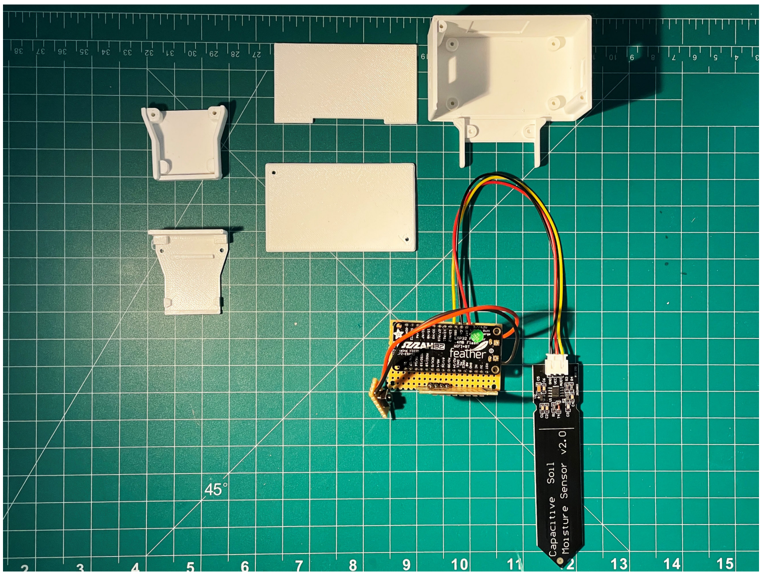
## Appendix Q. Building up *the CloudPlanter*

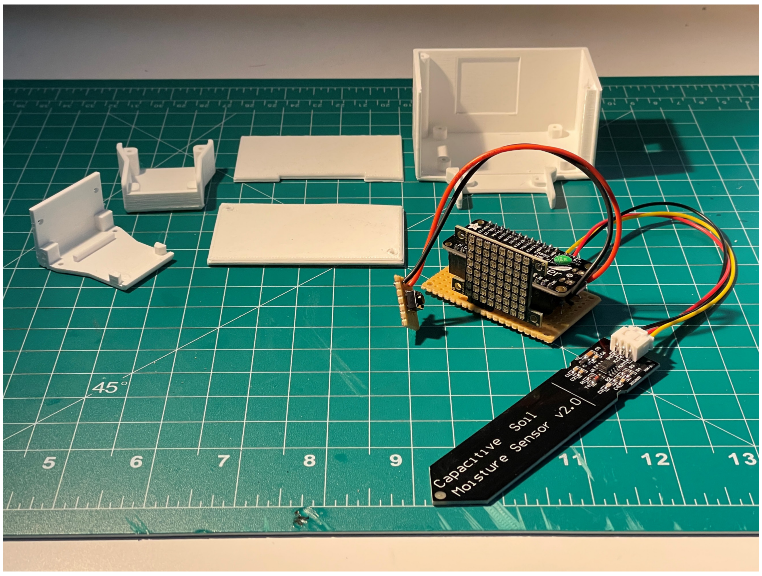


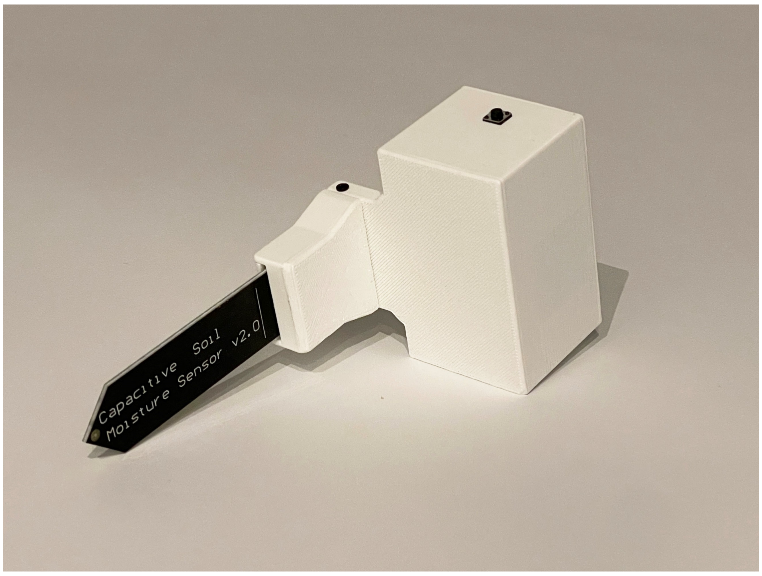


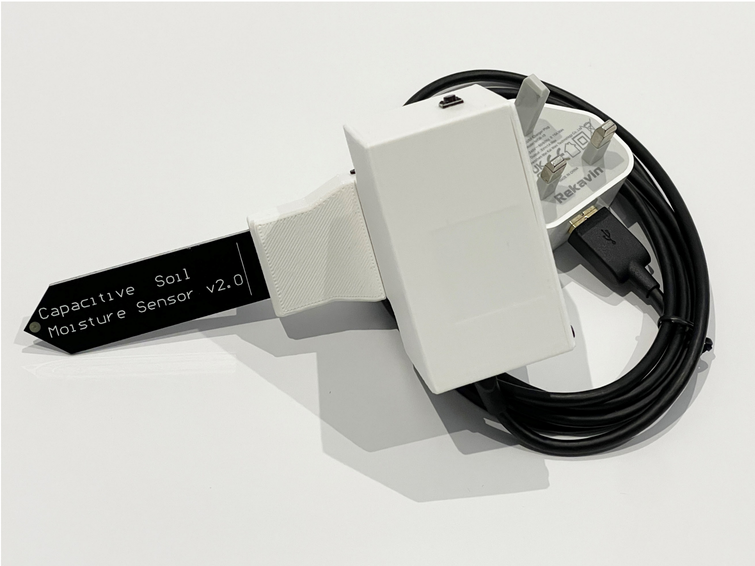


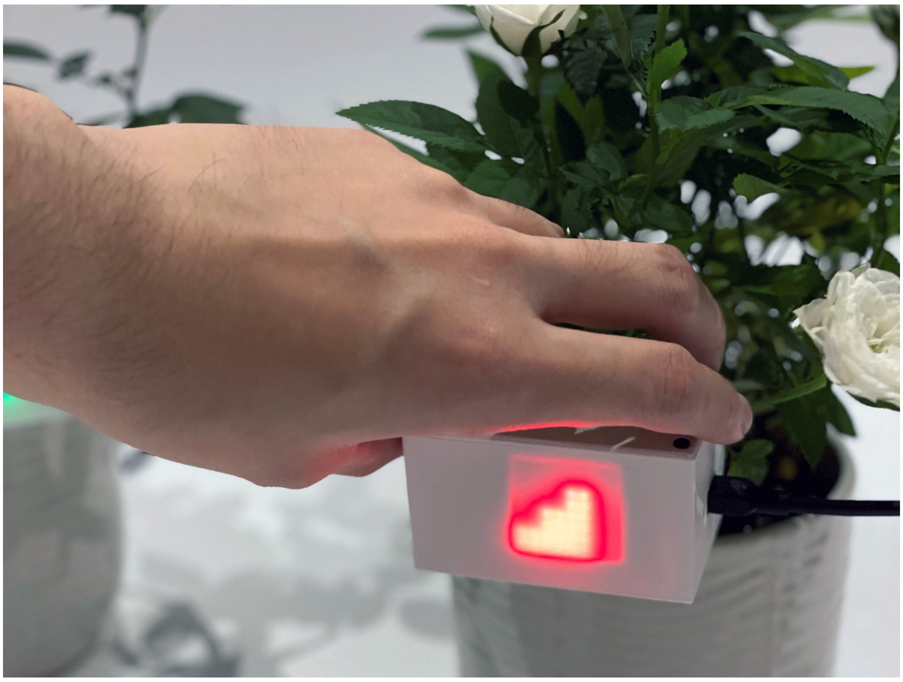


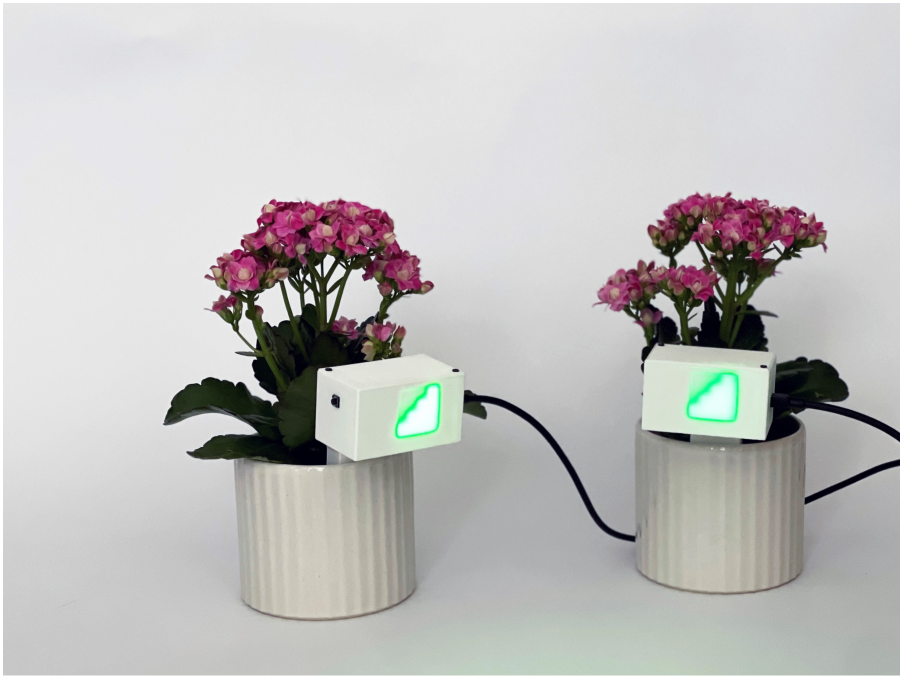

Capacitive Soil
Moisture Sensor v2.0
45°


Capacitive Soil
Moisture Sensor v2.0
45°


Capacitive Soil
Moisture Sensor v2.0


Capacitive Soil
Moisture Sensor v2.0
Rekavin





# Appendix R. Arduino Code for *the CloudPlanter*

```
#include <WiFiManager.h> // https://github.com/tzapu/WiFiManager
//#include <WiFi.h>
#include "secrets.h"
#include "ThingSpeak.h" // always include thingspeak header file after other header
files and custom macros
// Adafruit_DotStarMatrix example for single DotStar LED matrix.
// Scrolls 'Adafruit' across the matrix.
#include <SPI.h>
#include <Adafruit_GFX.h>
#include <Adafruit_DotStarMatrix.h>
#include <Adafruit_DotStar.h>
#include <Fonts/TomThumb.h>

#define DATAPIN    18
#define CLOCKPIN   5
#define BRIGHTNESS 15

Adafruit_DotStarMatrix matrix = Adafruit_DotStarMatrix(
                                  8, 8, DATAPIN, CLOCKPIN,
                                  DS_MATRIX_BOTTOM     + DS_MATRIX_LEFT +
                                  DS_MATRIX_ROWS + DS_MATRIX_PROGRESSIVE,
                                  DOTSTAR_BGR);

const uint16_t primaryColors[] = {
  matrix.Color(255, 0, 0), matrix.Color(0, 255, 0), matrix.Color(0, 0, 255)
};

uint32_t color = 0xFF0000;
uint32_t color1 = 0x00FF00;
uint32_t color2 = 0x0000FF;


WiFiClient  client;
unsigned long myChannelNumber1 = SECRET_CH_ID1;
unsigned long myChannelNumber2 = SECRET_CH_ID2;
const char * myWriteAPIKey = SECRET_WRITE_APIKEY;
const char * myReadAPIKey = SECRET_READ_APIKEY;

// These constants won't change. They're used to give names to the pins used:
const int analogInPin = A2;  // Analog input pin that the potentiometer is attached
to
int sensorValue = 0;        // value read from the pot
int soilmoisture = 0;
int palsoil = 0;      // value read from the cloud
int prepalsoil = 0;
const int buttonPin = 14;
int buttonState = 0;
int previousbuttonState = 0;
unsigned long previousDatatime = millis();
```

```
long timeInterval = 60000;
String leveldecider = "";

void setup() {
  // Serial.begin(115200);

  // Serial.println("\nDotstar Matrix");
  matrix.begin();
  matrix.setBrightness(15);
  // matrix.setFont(&TomThumb);
  // matrix.setTextWrap(false);
  //WiFiManager, Local intialization. Once its business is done, there is no need to
keep it around
  WiFiManager wm;


  bool res;
  // res = wm.autoConnect(); // auto generated AP name from chipid
  // res = wm.autoConnect("AutoConnectAP"); // anonymous ap
  res = wm.autoConnect("AutoConnectAP","password"); // password protected ap

  // if(!res) {
  //   Serial.println("Failed to connect");
  //   // ESP.restart();
  // }
  // else {
  //   //if you get here you have connected to the WiFi
  //   Serial.println("connected...yeey :)");
  // }
  ThingSpeak.begin(client);  // Initialize ThingSpeak
}


void loop() {
  buttonState = digitalRead(buttonPin);
  //Serial.print("button state:");
  //Serial.println(buttonState);
  sensorValue = analogRead(analogInPin);
  sensorValue = map(sensorValue, 0, 4095, 0, 1023);
  soilmoisture = map(sensorValue, 233, 725, 100, 0);
  //upload and download
  if (millis() - previousDatatime > timeInterval) {
    int statusCode = 0;
    // Serial.print("my Sensor = ");
    // Serial.println(sensorValue);
    // Serial.print("soilmoisture = ");
    // Serial.println(soilmoisture);
    // Write to ThingSpeak. There are up to 8 fields in a channel, allowing you to
store up to 8 different
```

```
    // pieces of information in a channel.  Here, we write to field 1.
    ThingSpeak.writeField(myChannelNumber1, 1, soilmoisture, myWriteAPIKey);
    // if(x == 200){
    //   Serial.println("Channel update successful.");
    // }
    // else{
    //   Serial.println("Problem updating channel. HTTP error code " + String(x));
    // }

    // Read from ThingSpeak. There are up to 8 fields in a channel, allowing you to
store up to 8 different
    // pieces of information in a channel.  Here, we read from field 2.
    palsoil = ThingSpeak.readIntField(myChannelNumber2, 1, myReadAPIKey);
    // Check the status of the read operation to see if it was successful
    statusCode = ThingSpeak.getLastReadStatus();
    // if(statusCode == 200){
    //   Serial.println("Pal Soil Mositture: " + palsoil);
    // }
    // else{
    //   Serial.println("Problem reading channel. HTTP error code " +
String(statusCode));
    // }

    if (palsoil - prepalsoil > 12 && prepalsoil != 0) {
      matrix.fillScreen(0);
      matrix.fill(color2, 0, 16);
      matrix.show();
      delay(800);
      matrix.fillScreen(0);
      matrix.fill(color2, 0, 32);
      matrix.show();
      delay(800);
      matrix.fillScreen(0);
      matrix.fill(color2, 0, 48);
      matrix.show();
      delay(800);
      matrix.fillScreen(0);
      matrix.fill(color2, 0, 64);
      matrix.show();
      delay(800);
      matrix.fillScreen(0);
      matrix.show();
      delay(800);
      matrix.fill(color2, 0, 64);
      matrix.show();
      delay(800);
      matrix.fillScreen(0);
      matrix.show();
```

```
      delay(800);
      matrix.fill(color2, 0, 64);
      matrix.show();
      delay(800);
      matrix.fillScreen(0);
      matrix.show();
      delay(800);
      matrix.fill(color2, 0, 64);
      matrix.show();
      delay(800);
      matrix.fillScreen(0);
      displaymyPot();
    }else {
      displaymyPot();
    }
    prepalsoil = palsoil;
    previousDatatime = millis();
  }

  //press the button
  if (buttonState == 1 && buttonState != previousbuttonState){
    ThingSpeak.writeField(myChannelNumber1, 2, buttonState, myWriteAPIKey);
    // Serial.print("button state:");
    // Serial.println(buttonState);
    displaypalPot();
    delay(5000);
    displaymyPot();
  }
}

void displaymyPot() {
  if (soilmoisture <= 100 && soilmoisture >= 75) {
    leveldecider = "level4";
    matrix.fill(color1, 0, 8); // 'On' pixel at head
    matrix.fill(color1, 8, 8);
    matrix.fill(color1, 18, 6);
    matrix.fill(color1, 26, 6);
    matrix.fill(color1, 36, 4);
    matrix.fill(color1, 44, 4);
    matrix.fill(color1, 54, 2);
    matrix.fill(color1, 62, 2);
    matrix.show();
  }else if (soilmoisture < 75 && soilmoisture >= 50) {
    leveldecider = "level3";
    matrix.fill(color1, 0, 6); // 'On' pixel at head
    matrix.fill(color1, 8, 6);
    matrix.fill(color1, 18, 4);
    matrix.fill(color1, 26, 4);
```

```
    matrix.fill(color1, 36, 2);
    matrix.fill(color1, 44, 2);
    matrix.fill(0, 6, 2); // 'On' pixel at head
    matrix.fill(0, 14, 2);
    matrix.fill(0, 22, 2);
    matrix.fill(0, 30, 2);
    matrix.fill(0, 38, 2);
    matrix.fill(0, 46, 18);
    matrix.show();
  }else if (soilmoisture < 50 && soilmoisture >= 25) {
    leveldecider = "level2";
    matrix.fill(color1, 0, 4); // 'On' pixel at head
    matrix.fill(color1, 8, 4);
    matrix.fill(color1, 18, 2);
    matrix.fill(color1, 26, 2);
    matrix.fill(0, 4, 4); // 'On' pixel at head
    matrix.fill(0, 12, 4);
    matrix.fill(0, 20, 4);
    matrix.fill(0, 28, 36);
    matrix.show();
  }else if (soilmoisture < 25 && soilmoisture >= 0) {
    leveldecider = "level1";
    matrix.fill(color1, 0, 2); // 'On' pixel at head
    matrix.fill(color1, 8, 2);
    matrix.fill(0, 2, 6); // 'On' pixel at head
    matrix.fill(0, 10, 54);
    matrix.show();
  }
  // Serial.println(leveldecider);
}

void displaypalPot() {
  if (palsoil <= 100 && palsoil >= 75) {
    leveldecider = "level4";
    matrix.fill(color, 0, 8); // 'On' pixel at head
    matrix.fill(color, 8, 8);
    matrix.fill(color, 18, 6);
    matrix.fill(color, 26, 6);
    matrix.fill(color, 36, 4);
    matrix.fill(color, 44, 4);
    matrix.fill(color, 54, 2);
    matrix.fill(color, 62, 2);
    matrix.show();
  }else if (palsoil < 75 && palsoil >= 50) {
    leveldecider = "level3";
    matrix.fill(color, 0, 6); // 'On' pixel at head
    matrix.fill(color, 8, 6);
    matrix.fill(color, 18, 4);
```

```
    matrix.fill(color, 26, 4);
    matrix.fill(color, 36, 2);
    matrix.fill(color, 44, 2);
    matrix.fill(0, 6, 2); // 'On' pixel at head
    matrix.fill(0, 14, 2);
    matrix.fill(0, 22, 2);
    matrix.fill(0, 30, 2);
    matrix.fill(0, 38, 2);
    matrix.fill(0, 46, 18);
    matrix.show();
  }else if (palsoil < 50 && palsoil >= 25) {
    leveldecider = "level2";
    matrix.fill(color, 0, 4); // 'On' pixel at head
    matrix.fill(color, 8, 4);
    matrix.fill(color, 18, 2);
    matrix.fill(color, 26, 2);
    matrix.fill(0, 4, 4); // 'On' pixel at head
    matrix.fill(0, 12, 4);
    matrix.fill(0, 20, 4);
    matrix.fill(0, 28, 36);
    matrix.show();
  }else if (palsoil < 25 && palsoil >= 0) {
    leveldecider = "level1";
    matrix.fill(color, 0, 2); // 'On' pixel at head
    matrix.fill(color, 8, 2);
    matrix.fill(0, 2, 6); // 'On' pixel at head
    matrix.fill(0, 10, 54);
    matrix.show();
  }
  // Serial.println(leveldecider);
}
```

# Appendix S. Co-Speculation Experiment Consent Form

Royal College of Art
RESEARCH& INNOVATION

**Participant Project Information & Consent Form***

(One signed copy of this form should be retained by the Participant and one copy by the Project Researcher)

*Co-speculation Experiment*

*Connecting through living with the CloudPlanters*

For further information
Supervisor: Dr Bjorn Sommer
*Bjorn.sommer@rca.ac.uk*

*22/09/2023*

Dear Participant,

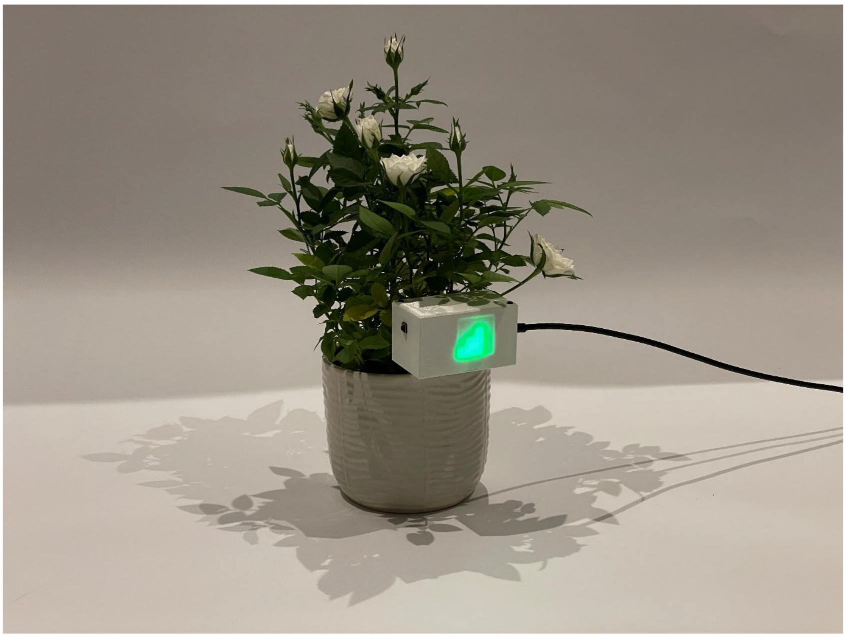
*I am Jerry Zidong Lin a PhD candidate* in Design Research at the Royal College of Art. As part of my PhD research, *I am* conducting a co-speculation experiment entitled *Co-speculation: Connecting through Living with the CloudPlanters.* My PhD research entitled *Pleasure-driven Experience Design though the Transformation from Analogue Products to IoT Products*. It applies a research-through - design approach to develop new experience design methods for fulfilling users' psychological needs and eliciting pleasure by transforming analogue products into IoT products. This experiment specifically concentrates on speculating about the future relationship between humans and IoT products.

If you consent to participate, you this will involve:

**Please confirm that you are not allergic to soil and plants and do not have red-green colour blindness before participating in this experiment!**

**Research Office** Royal College of Art Kensington Gore London SW7 2EU
t +44 (0)20 7590 4126 f +44 (0)20 7590 4542 research@rca.ac.uk www.rca.ac.uk/research

You will be provided with a pair of CloudPlanters along with two plants. The CloudPlanter (see the following image) is an IoT plant pot designed to upload real-time soil moisture data to the cloud. It displays graphical representations of soil moisture levels in your own pot and that of the person you care about. Additionally, it notifies you if your loved one has watered their plant within the last minute. You will need to set up the CloudPlanter by connecting it to the Wi-Fi network at your home, following the instructions in the PDF file titled "The CloudPlanter Instructions". The CloudPlanter will only detect data related to soil moisture in the pot, and no privacy-related data will be collected.



You need to invite a loved one who does not share your living space to use one of the CloudPlanters, forming a pair. Both of you will use your CloudPlanter for 10 days. Please ensure that both you and your chosen partner read and sign this consent form.

Place the CloudPlanters on your working desk or in a location that easily catches your attention. During these 10 days, use the CloudPlanter to monitor the soil moisture in your pot and in your partner's pot. You will receive an animated notification if your partner has watered their plant within the last minute. Based on this information from the CloudPlanter, you can decide on your next activity - whether to have a conversation with your partner via phone, text, or in person, or simply do nothing. Both you and your loved one are required to take photos of the CloudPlanter in your respective homes on the 1st and the 10th days of the experiment, and then send them to the researcher. During the experiment, you must record the times you water your plant, check your partner’s soil moisture, and notice that your partner has watered their plant, using the table sheet provided.

The CloudPlanter will only detect data related to soil moisture in the pot and the time you press the button, and no privacy-related data will be collected.

After 10 days, please return both the plants and the CloudPlanters to the researcher. Both you and your chosen partner will be invited to fill in an online questionnaire and participate in separate interviews to share your experiences of living with the CloudPlanter. These interviews will be voice recorded. Later, these recordings will be transcribed into a written script for data analysis purposes.

As a token of appreciation for completing this experiment, both you and your loved one will receive a £25 Amazon voucher.

At no point will any individual be identified in any reports resulting from this study. You will be anonymized (e.g., referred to as P1, P2, P3...) in future publications and the PhD thesis. Images or quotes that may allow you to be identified will only be used with your explicit permission. Your data will be stored securely and will only be used for my PhD thesis and related academic publications. Once my PhD is complete, all the data will be permanently deleted.

**Important! When you are living with the CloudPlanter, please ensure that you follow the safety guidelines below:**

**Read the PDF file "CloudPlanter instructions" in full to familiarise yourself with the device before the first use.**

**The CloudPlanter can only be used by adults aged 18 years and older.**

**Keep the CloudPlanter and its cord out of reach of children under 8 years of age.**

**Do not plug in the device with wet hands. Ensure that your CloudPlanter always maintains a minimum distance of 1 metre from power sockets, especially when watering your plant.**

**Use this device only for its intended purpose, as specified for this experiment.**

**Do not use it with a voltage converter.**

**Do not operate the appliance if it has a broken cord or plug or if it malfunctions. Please contact the researcher in such cases.**

**If the supply cord is damaged, it must be replaced by the researcher.**

If you have any concerns or would like to know the outcome of this project, please contact me at zidong.lin@network.ac.uk or my supervisor at bjorn.sommer@rca.ac.uk.

Thank you for your interest.

I *(please print)* …………………………………. have read the information above and all queries have been answered to my satisfaction. I agree to voluntarily participate in this research and give my consent freely. I understand that I can withdraw my participation from the project up to the point of publication, without penalty, and do not have to give any reason for withdrawing.

I understand that all information gathered will be stored securely, and my opinions will be accurately represented. Any data in which I can be clearly identified will be used in the public domain only with my consent.

Participant Signature…………………………………………………………………

Researcher Signature…………………………………………………………………

Date: ………………………………………………………………………

**Complaints Procedure:**

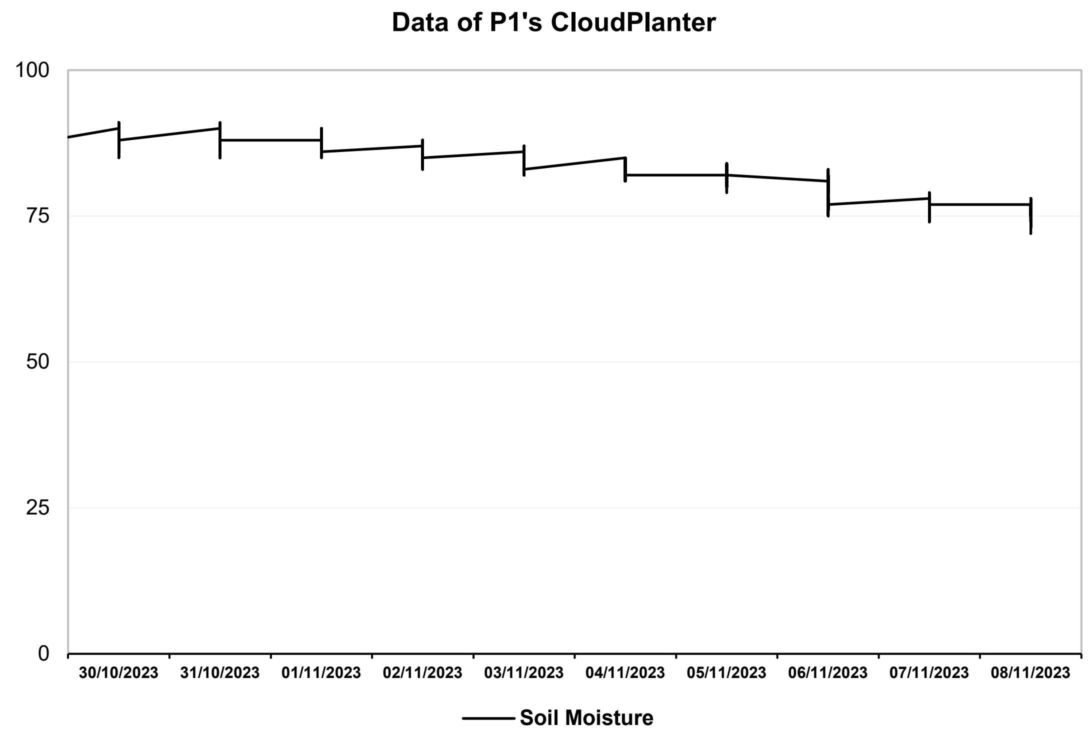
This project follows the guidelines laid out by the Royal College of Art Research Ethics Policy.

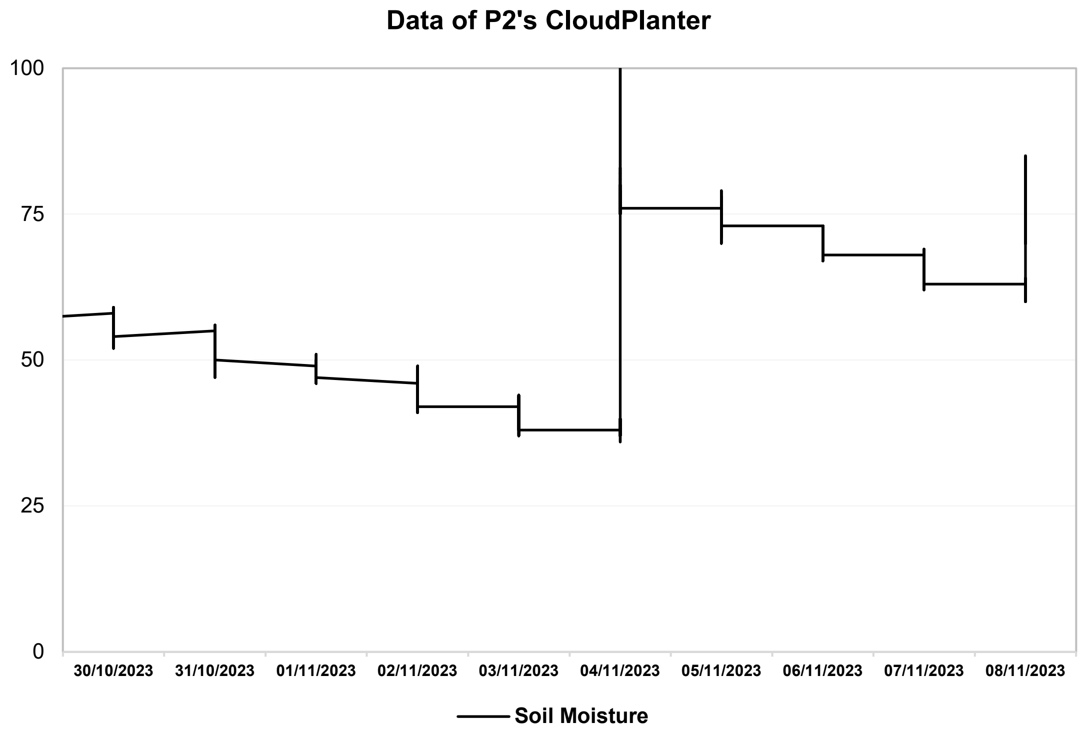
If you have any questions, please speak with the researcher. If you have any concerns or a complaint about the manner in which this research is conducted, please contact the RCA Research Ethics Committee by emailing ethics@rca.ac.uk or by sending a letter addressed to:

The Research Ethics Committee
Royal College of Art
Kensington Gore
London
SW7 2EU

# Appendix T. Co-Speculation Experiments Results

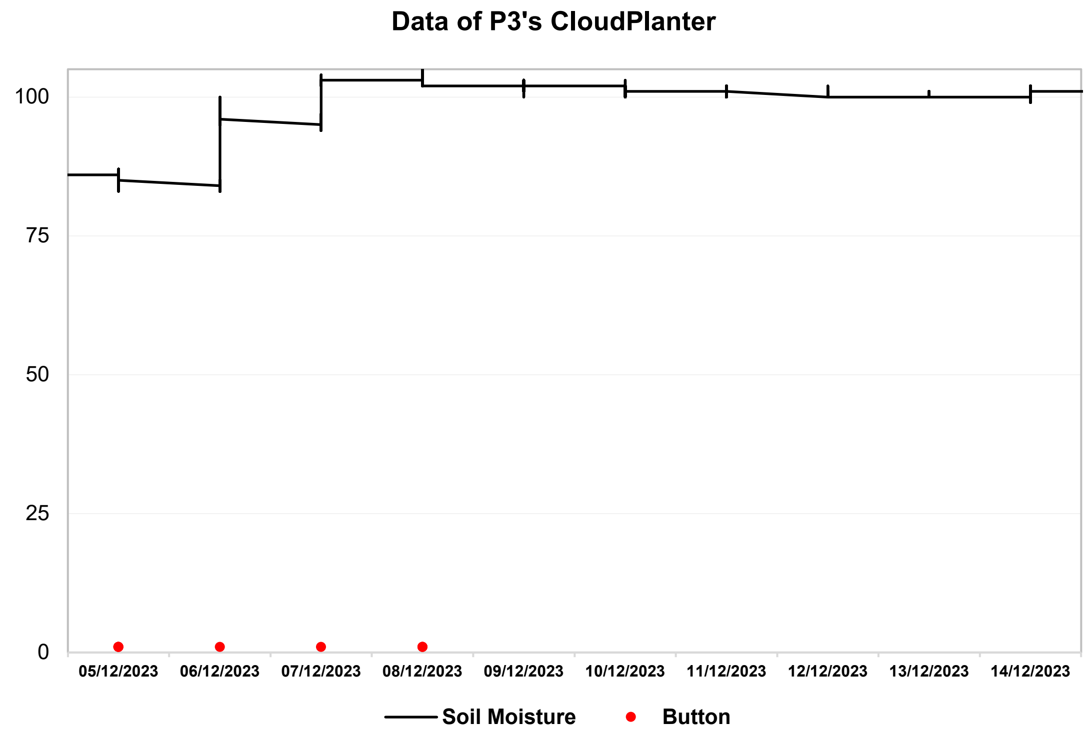
## Group 1 (P1 and P2)

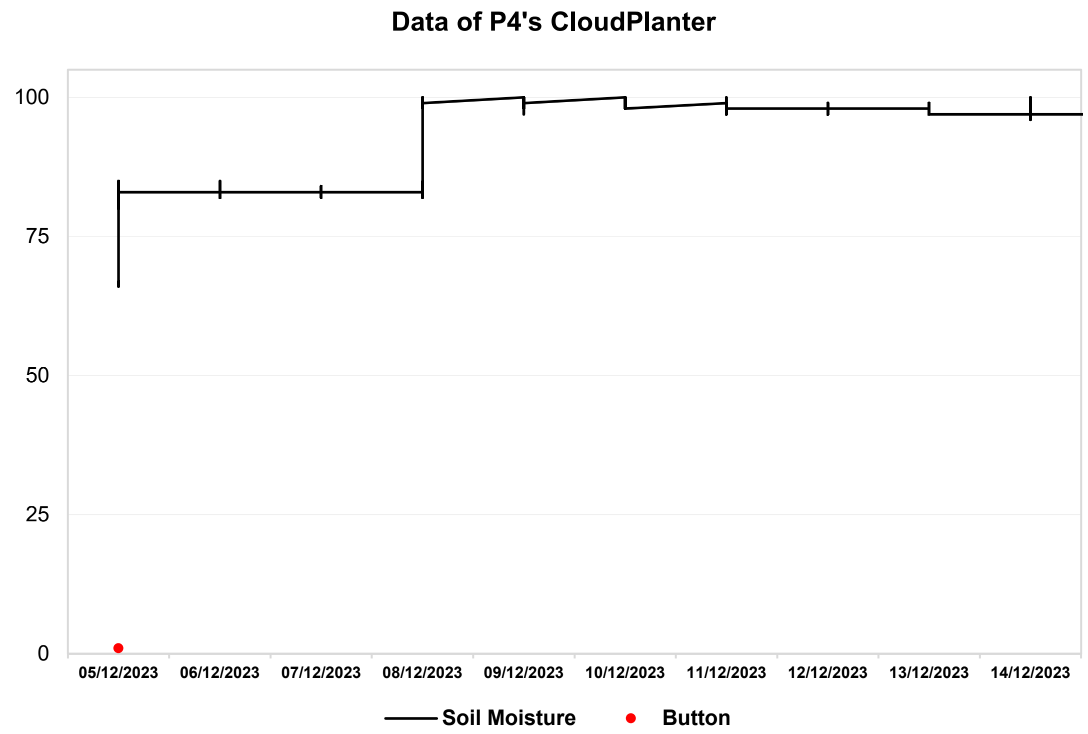




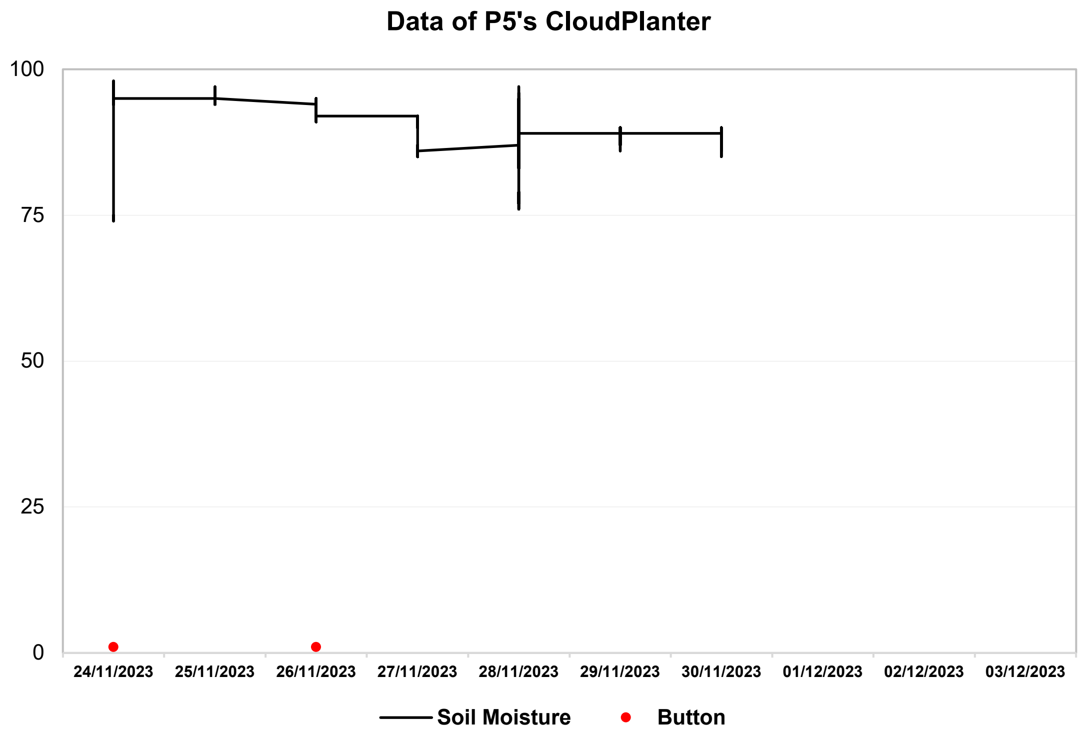
Data of P2's CloudPlanter
100
75
50
25
0
30/10/2023
31/10/2023
01/11/2023
02/11/2023
03/11/2023
04/11/2023
05/11/2023
06/11/2023
07/11/2023
08/11/2023
Soil Moisture

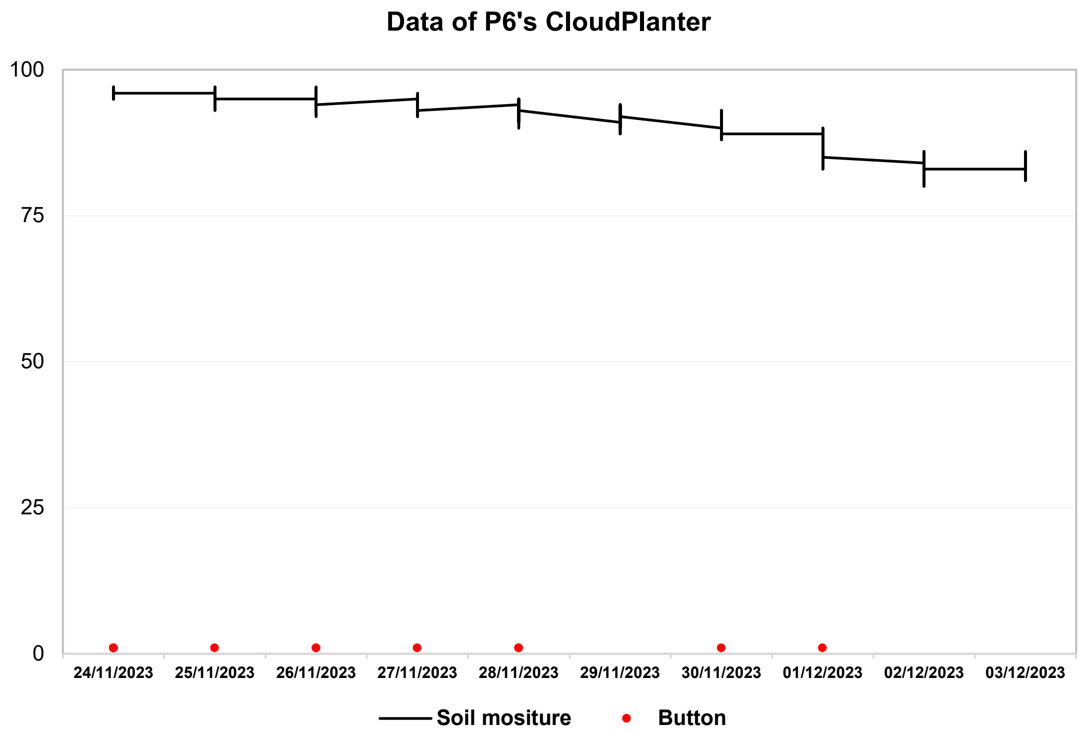
**Group 2 (P3 and P4)**



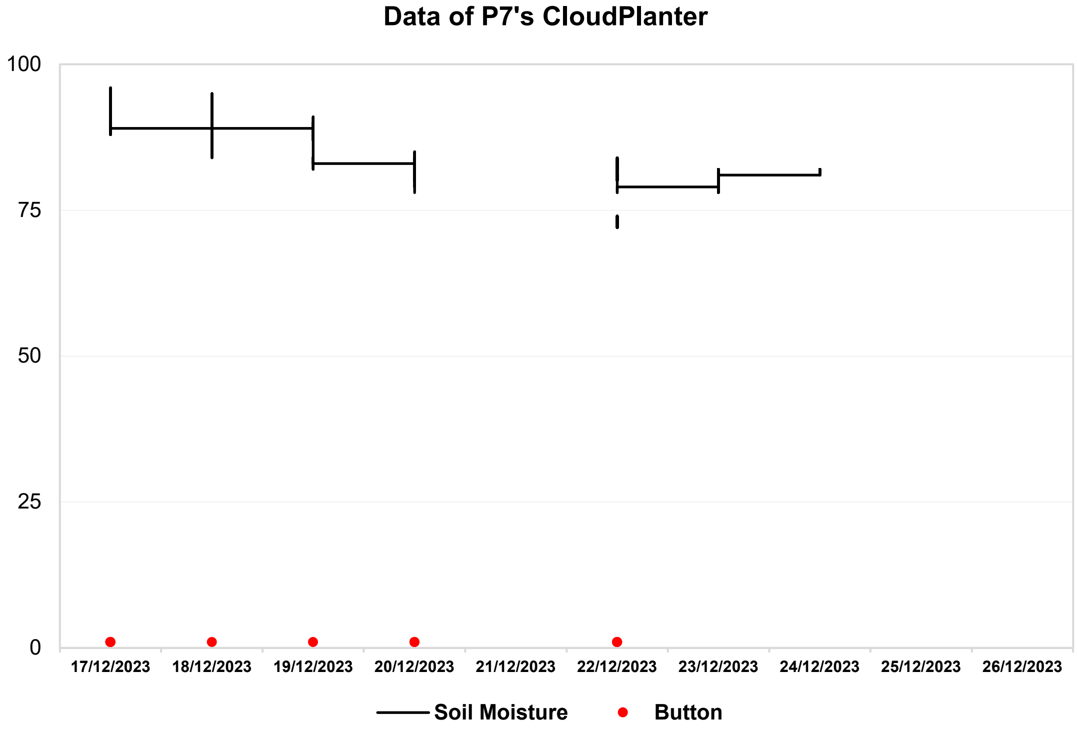



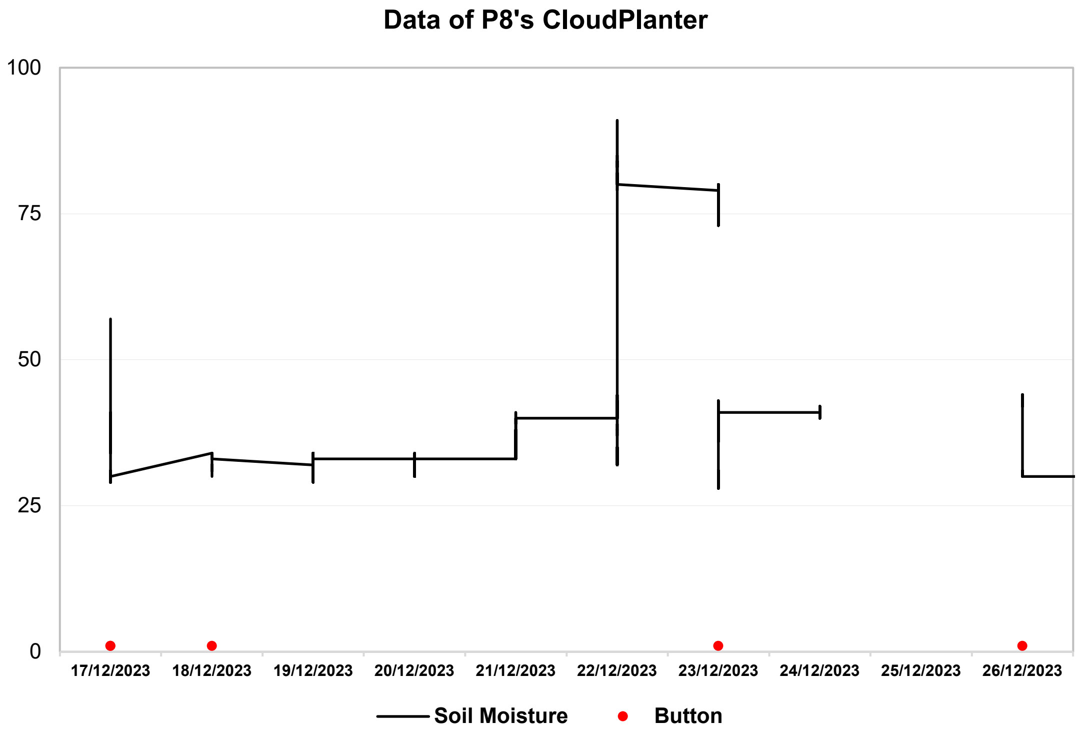
## Group 3 (P5 and P6)



**Group 4 (P7 and P8)**



# Appendix U. Co-Speculation Experiment Questionnaire

### ***The CloudPlanter*** **Experiment Feedback**

Dear Participants,

Thank you for taking part in my *CloudPlanter* Experiment!
To gather feedback about your experience with the *CloudPlanter*, please take a moment to answer the following questions. Your insights are incredibly valuable to this research.
Be assured that all information collected will remain confidential. The data gathered will be stored securely, and upon analysis, all personal information will be securely destroyed. No individual participant will be identified in any reports or publications resulting from this study.
I appreciate your time and participation.

Best regards,
Jerry Zidong Lin

### Complaints Procedure:

This project follows the guidelines laid out by the Royal College of Art Research Ethics Policy. If you have any questions, please speak with the researcher. If you have any concerns or a complaint about the manner in which this research is conducted, please contact the RCA Research Ethics Committee by emailing ethics@rca.ac.uk or by sending a letter addressed to:

The Research Ethics Committee
Royal College of Art
Kensington Gore
London
SW7 2EU

**Q1. Name:**

[ ]

**Q2. Age Group**

☐18-25 ☐26–35 ☐36–45 ☐46–55 ☐56-65 ☐ Above 65

**Q3. Nationality:**

[ ]

**Q4. How easy or difficult did you find it to set up the CloudPlanter?**
The setup process involves the initial connection of *the CloudPlanter* to the Wi-Fi in your residence.

☐Extremely difficult

☐Very difficult

☐Slightly difficult

☐Neutral

☐Slightly easy

☐Very easy

☐Extremely easy

**Q5. How helpful was the 'CloudPlanter Instruction' document in understanding how to interact with *the CloudPlanter*?**

☐Extremely unhelpful

☐Very unhelpful

☐Slightly unhelpful

☐Neutral

☐Slightly helpful

☐Very helpful

☐Extremely helpful

**Q6. How would you rate your overall experience of the experience with *the CloudPlanter*?**

☐Extremely unpleasurable

☐Very unpleasurable

☐Slightly unpleasurable

☐Neutral

☐Slightly pleasurable

☐Very pleasurable

☐Extremely pleasurable

**Q7. To what extend do you enjoy taking care of indoor plants before using *the CloudPlanter*?**

☐Extremely uninterested

☐Very uninterested

☐Slightly uninterested

☐Neutral

☐Slightly interested

☐Very interested

☐Extremely interested

**Q8. To what extend do you enjoy taking care of indoor plants after using *the CloudPlanter*?**

☐Extremely uninterested

☐Very uninterested

☐Slightly uninterested

☐Neutral

☐Slightly interested

☐Very interested

☐Extremely interested

**Q9. How would you describe your level of relatedness with your partner BEFORE using *the CloudPlanter*?**

☐Extremely unconnected

☐Very unconnected

☐Slightly unconnected

☐Neutral

☐Slightly connected

☐Very connected

☐Extremely connected

**Q10. How would you describe your level of relatedness with your partner AFTER using *the CloudPlanter*?**

☐Extremely unconnected

☐Very unconnected

☐Slightly unconnected

☐Neutral

☐Slightly connected

☐Very connected

☐Extremely connected

**Q11. How positive was the influence of *the CloudPlanter* on your relationship with your partner?**

☐Extremely negative

☐Very negative

☐Slightly negative

☐Neutral

☐Slightly positive

☐Very positive

☐Extremely positive

# Appendix V. Co-Speculation Experiment Interviews

The interview audio recordings were transcribed using Otter.ai. Transcriptions were lightly edited to maintain anonymity, correct minor grammatical errors, and complete incomplete sentences only where the intended meaning was clear. All edits were made to improve readability while preserving the original spoken style and meaning.

## Interviews of P1 and P2 (A psychologist and his daughter)

### A. User Feedback

1. Where have you placed the CloudPlanter in your home? Could you describe the lighting and humidity of the environment?

   **P1:** In my work room. I put it on my desk. Not too much sunlight. But the room has a window.

   **P2:** Right on the window beside my work desk. I guess it is similar to the interior of the house, but this is the window that has the most sun.

2. Have you had to move it for any reason, and if so, when did that happen?

   **P1:** No, no, I just put it there for the whole period.

   **P2:** No.

3. Could you tell me how easy or difficult you found setting up the CloudPlanter? Using a scale where -3 is ‘extremely difficult’ and 3 is ‘extremely easy’, what rating would you give the setup process?

   **P1:** It’s easy. So it’s quite easy. Very easy, number two.

   **P2:** Three.

4. Did you find the instructions clear and helpful enough for understanding how to interact with the CloudPlanter?

**P1:** It's easy to understand, except there was one question about the password.

**P2:** Yeah, it was simple enough.

5. How many times did you water your plant?

**P1:** I think about three times. When the level was going down, I watered it. I tried my best to water all around. I saw the indicators going down, so I watered all around the pot and that's it. When I unplugged it, I watered it again. So when the project was finished, I unplugged it and returned the plant to you. It took time, so I watered it to prevent it from getting too dry.

So how many times did you notice your partner watering his plants through the animation displayed on your CloudPlanter?

**P2:** I don't think I've actually seen the blue. No.

6. How often did you check the soil moisture in your partner's planter during the experiment?

**P1:** Every three days. I might pass by and look at the light. If the light was on, green colour, then it was okay. I only watered two times for the whole period. No, I didn't check hers by pressing the button. I asked her to monitor it by herself. Because I was at her home from time to time, when I walked in, I looked at the plant.

**P2:** I think every time when I wanted to water my plant, I pressed the button to see if he did it. I think he's better at it than I am. Mine was probably hovering around three. It was never really four.

7. What is your emotional response after checking the soil moisture in your daughter's CloudPlanter?

**P1:** I feel okay. Yeah, it's okay. Everything is okay, fine.

**P2:** Yeah, it's almost like I want to see how he's doing. And I want to kind of it's almost like a competition, but not quite. And I guess it gives me that connection.

That human connection shouldn't really be there. It has that human connection piece in there. But somehow you feel like, oh, he's not there, so I'm kind of communicating with a plant. Living being, yes, but it's almost like it's more than just a machine. But like if you put it on a spectrum, you have the human here and then you have the machine here. And it's somewhere in the middle of the spectrum. I would say it's more like a conduit for me.

8. Can you tell me about how many times you've spoken with your daughter about the CloudPlanter and the plant? What topics came up in those conversations?

   **P1:** About three times. First, the introduction and asking for consent. The last was letting her know about the completion. And the one in the middle was just checking if everything was okay. She said okay.

   **P2:** I would say twice within that period. First one, I think it was, you know, whether I had set it up correctly. He came over to check it out. And then I think the second time was kind of reminding each other whether we were remembering to water. And I think that those were the two conversations that we had.

9. How did the CloudPlanter influence your relationship or communication with your partner?

   **P1:** Just a little bit. One more topic to talk about.

   **P2:** Influence? I guess it depends on how you classify influence. Because for us, we're in constant contact, we see each other every day, we live very close to each other. So it adds a little, a different aspect to the conversation, but it's not essential. But I can see if we were living further apart, then there would be an additional something that connects us.

10. What is your emotional response after having a conversation with your daughter triggered by the CloudPlanter?

    **P1:** Just a little bit of ease. The feeling of ease. Okay, she accepted the project and followed her instruction.

**P2:** Just a little bit of ease. The feeling of ease. Okay, she accepted the project and followed her instruction.

11. Thinking back over the past week, how much did you enjoy using the CloudPlanter? On a scale of -3 for 'extremely unpleasurable' to 3 for 'extremely pleasurable', where would you rate your experience? Could you explain why?

**P1:** Very pleasurable. First of all, I liked the plant. Second, I liked the project. At least we could do something to understand something. And third, it was successful and completed.

**P2:** I would say around a two. Personally, I'm a very competitive person by nature. Instead of just going through my daily routine to water my plants, it became something like a competition with him to see how he's doing, to see if he's keeping on top of things.

12. Could you share some of the most pleasurable moments you had with the CloudPlanter? What does pleasure mean to you in this context, and what do you think triggered these pleasurable moments?

**P1:** I think the last moment. Oh, the project was completed! And the plant was okay. The most important thing was the plant was okay. Was the plant still alive? Yeah. And the project was completed. This was the most exciting moment. Because I worried that if I didn't take care of the plant, it would die. I didn't want that to happen.

**P2:** I would say just pressing that button and seeing the red come on. If I'm a three, and he's a two, or if I'm higher than him, I feel like I've done something or achieved something.

13. Do you feel you are more connected to your partner while you are using the CloudPlanter in this experiment? Why or why not?

**P1:** A little bit more. As I said, one more topic.

**P2:** Yeah, I would say it's kind of like an invisible connection somehow. Even though we're on the phone all the time and texting each other all the time, I think having that living plant actually makes it a different experience.

14. What was the least pleasurable part of using the CloudPlanter for you? Would you mind sharing why?

**P1:** Just a little feeling that I had to do one more thing.

**P2:** I don't think there was anything unpleasurable. I would say the only thing is, not unpleasurable, but I would have wished for a longer testing period. Because I felt like I was just getting into the routine. Comparatively speaking, I think it's a bit big for the size of the plant. The interaction was pretty straightforward and easy to use, and I enjoyed pressing that button. Normally you would only water the plant or trim it, right? But just the physical touching of the button actually makes you connect with it in a different way. And it almost looks like the plant is trying to speak to you.

15. Would you like to use the CloudPlanter in the future? What improvements would you suggest for the CloudPlanter and why?

**P1:** Yeah. I don't know. But as I said, I like flowers. So if possible, I would like to do something more

**P2:** Especially if it's someone other than my dad, like a good friend of mine who lives overseas and we normally wouldn't have that kind of interpersonal connection. But I think that would be something that I would like to try to do with her because it gives us that connection, otherwise the phone or the texts won't be able to. I mean, if you ever complete the project, and you have no use for them, I would actually like to send one to my girlfriend in Canada because we're very close. She actually came to visit us in October, but I text her almost every day. But like I said, it gives us that extra level of connection. And I think it'd be something good to have.

**B. Psychology Reflections**

1. Do you feel that the CloudPlanter fulfilled your psychological need for relatedness? Why? Can you tell me why you feel that way and how you define the psychology need for relatedness as a psychologist?

   **P1:** Yeah. Because a plant is a very good thing for people to have a kind of relationship building. First, I think relationship building can be human to plant, and then maybe it can also extend to human to human. First of all, I take care of the plant, so therefore I have a relationship with the plant every day. And then I can talk with other people about the plant. So throughout the process, I can improve the relationship with other people. I think relationships are important for everybody, but everybody may need different kinds of relationships. The relationship with a plant is the easiest and the starting point for people to build relationships. I think building a relationship with plants is easier than building relationships with animals. Because you need more care, more time, more effort, and more money to build a relationship with an animal. But a plant is easier because it is simpler. At the same time, you can see the growth of the plant, and from that growth, you can have a feeling of being successful and being accepted.

2. How do you think the CloudPlanter could be improved to better fulfil users' psychological need for relatedness?

   **P1:** I think the design with a button, just a mechanical one, could be improved. If you can encourage people to have more face-to-face interaction, it will be much better. Maybe face-to-face interaction or through telephone calls? When I have interaction with my daughter, I can ask, "How's the plant?" Yeah, something like that, instead of just pressing the button. If you have only a button, when the water is not enough, and you call them, it's too late. That is only problem solving. But for more intimate relationship building, it should be more. Intimate means more physical connection. That's why usually I do not press the button. When I see her, I ask her. Because I visited her place from time to time, and therefore, when I walk into a room and look at the plant, if it's green, the colour is very good. That works.

3. Apart from relatedness, did you notice the CloudPlanter meeting any other psychological needs during the time you used it? Can you explain?

**P1:** No. Maybe, if you want me to make a suggestion, the period could be longer. Because it tests the patience of people. Right. And then it tests the relationship, whether it can be carried on for a longer time. Because with a longer period, there is more effort in taking care of the plant.

4. Have you ever grown plants at home using traditional planters? Do you find that the CloudPlanter is better at satisfying your psychological needs compared to those traditional planters? Why?

   **P1:** Yeah. Because I think with your design, we can check the humidity of the plant. I think that's important. Without that machine, most people will just go close to the plant and look at it, or put their finger in the soil and test the humidity. And that design is good. You can see from far away—oh, the green light, okay. And if it could be smaller, that would be better.

5. From a psychological perspective, would you describe your experience of using CloudPlanter as pleasurable?

   **P1:** People can… Because it's more easily accessible and easier to understand the plant, that will help people to watch. How can I say, to engage with the plant more easily. At least they have a feeling that it is easier to take care of the plant. Instead of every day just going close to the plant and putting my finger in, something like that. But this is easier. You can look, you can understand, and then once you put the water in, it will show up, the light will grow, and it's always enough. And then satisfaction will come up right away. That way, it encourages people to have more interest in taking care of a plant.

6. From a psychological perspective, would you be interested in using other IoT products like the CloudPlanter in the future? What are your reasons?

   **P1:** As I'm a psychologist, I can use this kind of thing as a means to promote clients to have more relationships with substances and also more relationships with people. This is one means, one kind of method. There are so many means you can use to help people build up relationships, but this is one of the ways. It's an easier way, a simple way. For example, if I'm doing a psychological experiment, if I can use this kind of device, I can have a connection with a group of my patients, for example, ten. So therefore, I can check it and I can connect with my patients through this media. But of course, you have to select the kind of plant that is easy to take care of.

**C. Psychology Evaluation**

1. When it comes to psychological needs, which types do you think might be better addressed by IoT products and why do you think that is?

   **P1:** Maybe competence. Maybe you can add in some competitive element in that area. Yeah. It will increase people's interest and engagement. People will have more energy to go to it. "Oh, I would like to win!"—something like that. Also, one element I think you put in, you said you would give a voucher, right? That's a kind of element to attract people to say, "Oh, good, I got something." Yeah. This is important.

2. Can you think of any other psychological theories that might help designers make IoT products more pleasurable? What makes these theories useful?

   **P1:** I think, first of all, the task-centred theory is really important. That means giving your participants something to do that is easy to do and gives them a sense of accomplishment or achievement. That's important; it's task-centred. And then the second one is a more difficult one. It's cognitive behaviour. You would like to change people's minds or thinking, cognitive thinking. You have to use something more practical for them to do and to see, and then they will see the result. And from the result, they will have a feeling of achievement. And then they will change their thinking. Don't just ask them, "Oh, you have to change your thinking." That's too abstract. But if you give them something to do, then they will fulfil it, and then have a sense of achievement, recognise it: "That was all good thinking, I had to change my thinking."

3. As a psychologist, what would be your approach to evaluate the pleasurabiliy of a product?

   **P1:** Okay. You have to ask the participants to tell you: are they happy? And then, do they have a feeling of achievement? Do they have a feeling of difficulties? That is the way you understand the participants' meaning or success in participating in your project. Don't let them feel that answering your question is an additional trouble—that is important. Maybe ask them to check your questionnaire. I think usually don't mention the theories. Don't use those technical terms, but transform those technical terms into practical actions. I think you have already asked a lot of questions about that. For example, their relationship building, their emotion, their sense of success, and things like that. But of course, you don't need to ask something more technical. Just ask: "Okay, do you feel happy?" and so on. And then transform those technical terms into behavioural terms. So we call it factor analysis—you develop those factors into behaviours

4. From the psychology perspective, do you have any other suggestions for experience designers on how they can enhance their products?

**P1:** Maybe at the beginning when you invite the participants, you could consider letting them know more about the purpose of your project. Not just the purpose from your side, but let them know what kind of contribution it will bring for them if they participate. That will increase their willingness to participate. And it may make them feel: "Oh, I am important by doing this project. I'm kind of encouraged in this way." Not just, "I know you invited me, so I will participate because I know you." No. You can make me feel that I can contribute more—in terms of the result of the project, and in terms of contributing to the general public. Make the participant feel: "I am important. I participate because I am important." For commercial users, as I said, for example, you could give them some coupons and points as a starting point to attract them. And then of course, you can introduce the product, showing how useful it will be. Because some projects will help the company develop this equipment in a more useful way, or something like that. And maybe also give them future hope: if this product is improved and put on the market, I will let you know, and maybe I will give you a free product, or maybe a discount. Something like that. That means the relationship is not only one-time but long-term. Because I am a merchant, and I'm doing an experiment right now. Later on, I will have a product, and then I will give it to you. And then you will introduce it to your friends. As I said, if you can prove this product is usable, then maybe I would like to have one later on. Because everyone has a plant at home, right? And then this kind of progression equipment would be good for me to know whether my plant is under-watered or over-watered. So it's a very good way to encourage people to participate in your project, and later on they will buy it, they will use it. Yeah, okay. Because I think in the market there are already some of these kinds of things, but they're not so electronic. But this is an electronic one, you can see it by the colour. But make it better looking!

## Interviews of P3 and P4 (Two master's students in the same programme not familiar with each other)

### A. Setting up

1. Where have you placed the CloudPlanter in your home? Could you describe the lighting and humidity of the environment?

   **P3:** I've placed it on the bedside table. As for the lighting, there's lamp light, and it's directly facing the window, but there's a bed between it and the window. I think the humidity is moderate.

   **P4:** I placed the pot on the table, which was located in my living room. And while there was not enough sunlight for the plant, because you know, it's wintertime and I tried to water it every day.

2. Have you had to move it for any reason, and if so, when did that happen? Why?

   **P3:** No, because it needs to be plugged in, and that spot is quite suitable.

   **P4:** No, I just kept it in the place.

3. Did you encounter any issues the first time you connected the CloudPlanter to the Wi-Fi at your residence?

   **P3:** No.

   **P4:** No, everything was fine. And the instruction was also fine.

4. Did you find encounter any issues in understanding how to interact with the CloudPlanter?

   **P3:** Actually, since you had introduced it to me, I had a general idea.

   **P4:** Yeah, really easy. Really easy.

### B. Personal feeling

1. How often did you water your plant, and what factors influenced your decision to do so?

   **P3:** At first, I think it was every day. Then about every one or two days, but after realising it was full, I watered it for the last time yesterday. I'm going to turn on the heating, and I'm worried that the room will be particularly dry. So, while turning on the heating, I watered it. Although the indicator light was always at the full level, I was afraid the plant would become very dry. I feel that when the heating is on, my skin gets very dry, and I think the plant might experience the same, so I watered it in advance.

   **P4:** Almost every day. Because I didn't know what kind of flower this was. And I couldn't look it up on the internet. I couldn't just research it. The first time I watered the plant, the green gauge bar was like three green bars, and the maximum was four. So to make it to the maximum bars, I tried to water the plant enough. And then I realised this plant didn't need as much water as I thought. So I tried to water the plant as little as I could every day. And I just tried to do that because I thought it could be part of my daily routine. And watering the plant itself made me wake up in the morning. So I liked that part. I think I watched the indicator bar every day, every time I watered the plant, but most of the time the indicator bar was always at four bars. So even if I saw the bar, I didn't really care about the number of bars. I just watered the plant.

2. How many times did you checking your partner's soil moisture? What is your emotional response after checking the soil moisture in your partner's CloudPlanter?

   **P3:** In the morning and afternoon. At first, I was a bit curious because I was the one who gave him the plant, and it was his first day. I wanted to see the soil moisture on the first day. Also, sometimes if I feel it's quite dry, I can remind him to water his plant, so I checked it.

   **P4:** Well, I tried a few times, but first there were some miscommunications between my friend and me. She couldn't get my signals, and I couldn't get her signals either. But after a few times, she said she could get my signals, but still I couldn't get hers. I think I didn't find the red. So that's the part I didn't quite understand. If I just pressed this button right on the side, I don't remember seeing the red signals. I think I've never seen the red one before. I think I pressed this button every time I watered the plant. But I didn't have enough time to press it often, because I'm always out of my house, always staying in the studio. And it was kind of like texting or saying hello in the morning. So I'm pretty sure it was a kind of positive feeling pressing those buttons.

3. Thinking back over the past week, how much did you enjoy using the CloudPlanter? Could you explain why?

**P3:** Regarding the atmosphere in the owner's room. I didn't have this kind of potted plant; I have flowers in a water bottle, but I feel this one improves my mood beyond its functions. Sometimes I lightly touch it, or when I see it and the light changes, I press the button, and it changes. Initially, I knew it was interactive. Sometimes when I'm bored, I also want to press it to create a dynamic atmosphere change in the room.

**P4:** Well, first of all, it was nice to have a flower in my house. And second, seeing those green bars was really interesting. Because it was like communicating with the plant. The only thing I felt was missing in this device was that if you're out of your house and cannot interact with your plant, then there's no way to interact with your friends with this device. So I think it'd be really helpful if you developed an application. Even if you're out of your house, you could still communicate with your friends.

4. Could you share some of the most pleasurable moments you had with the CloudPlanter? What does pleasure mean to you in this context, and what do you think triggered these pleasurable moments?

**P3:** The most delightful part is watching the LED lights change when watering. However, it was a bit awkward that day because we prearranged watering our plants, and I was supposed to water my plant first, but the level of my soil moisture was full. So my friend didn't see the blue light. Then, when he watered it, unexpectedly, I saw the light came on. I thought I wouldn't see anything with my device, but suddenly seeing it was quite novel, and indeed, it also facilitated communication, which was good.

**P4:** So, as I told you, this is winter season, and now I mostly keep my living room dark. And you know, these plants display green light bars. Just seeing those green bars in the dark room was kind of a pleasure for me because it felt like there was only me and this device. Watching those signals was actually peaceful and satisfying, made me calm.

5. Have you ever grown plants at home using traditional planters? Do you find that using the CloudPlanter is more pleasurable compared to those traditional planters? Why?

**P3:** I used to have succulents. The CloudPlanter might be more interesting because with regular plants, they're just a decoration when you don't water them, and there might be a little interaction when you water them. But it seems like, with the CloudPlanter beyond that, you can have even more interactions with it.

**P4:** I liked plants before, but it was not me who was taking care of the plants. It was my parents. This was my first time having a plant of my own in the house. If the device itself is not too expensive, then I'd always get a flower plant with this device in it. Because it can tell you when it's the appropriate time to water the plant, and also, like you intended, I could communicate with my friends even without texting "good morning" or "how are you." I could just check my friend's status through this device.

6. What was the least pleasurable part of using the CloudPlanter for you? Would you mind sharing why?

**P3:** It lights up at night, and since I place it by my bed, I can feel the soft glow when I go to sleep. Sometimes, I'll use a pillow or cushion to slightly shield the light on that side.

**P4:** Every time I checked the green bars of the plant, like I told you, the bars were always at maximum. They were always full bars. And it seemed like the plant didn't need me anymore, because it would have moist soil anyway. If you do the experiment with a plant that needs more water every day, then it would be really great, because it could seem like the plant needs me to water it.

### C. Partner

1. How far is your partner's residence from your place?

**P3:** I didn't ask him.

**P4:** I don’t know.

2. In average, how many times did you contact your partner per week?

   **P3:** Before, we didn’t have each other’s online contact information, but we exchanged it because of this experiment. Usually, we’d communicate in the studio and have conversations there. Probably because our workstations are close, he sits opposite me. When he arrives, I say hello, and when he leaves, I say goodbye. In between, if I have any questions about our studies, I would ask him.

   **P4:** I didn’t make any mobile contact, but she’s right in front of my desk. And every time she or I walk into the studio, we always said hello to each other. When we leave, we say goodbye, see you tomorrow. We sometimes share our opinions about each other’s projects. But outside of the studio, we never had any communication.

3. In average, how many times did you contact your partner per month?

   Not applicable to this pair of participants.

4. How many times did you contact and meet each other during the experiment?

   **P3:** I think there will be, because besides asking him, it actually feels like there’s an additional topic to discuss. And last time when watering, because I had watered before and he seemed to have watered once too, we missed each other’s timing without noticing. Then he suggested scheduling a time, which added another conversation to our interaction.

   **P4:** It really increased, because at first we didn’t know how to use this kind of device the right way, so we tried to sort out the problem together by using WhatsApp. And even after that, when she got up, I mean this appointment, she used WhatsApp to inform me about the interview. So yeah, but our relationship hasn’t developed much further, but still it’s improved compared to before.

5. How many times did you notice your partner watering his/her plant through the animation displayed on your CloudPlanter?

**P3:** Only once. But before our scheduled time, he said he watered it that morning, but I wasn't awake at that time.

**P4:** She said she could see me watering the plant. But every time I tried to see her watering the plant, we made a promise, like, after the studio at 11pm, she said she was going to water the plants. So I would be there to watch her watering. But sometimes, her plant was already full of moisture. So she couldn't water when she planned, and sometimes she just forgot to water at the right time. So till now, I haven't seen her watering the plant.

6. Can you tell me about how many times you've spoken with your partner about the CloudPlanter and the plant? What topics came up in those conversations?

**P3:** About 8 times. Sometimes he doesn't reply to messages. I don't know if it's a personality issue or just the way he is. Normal communication regarding our studies.

**P4:** I remember pressing this red button like eight or nine times, but I haven't done it these days because I was really busy. It was bad timing, because we had to prepare for our final assessment. And we didn't have any time to talk about those kinds of casual topics. We got into the studio in the morning and left late at night.

7. What is your emotional response after having a conversation with your partner triggered by the CloudPlanter?

**P3:** Actually, because my English isn't very good, I feel nervous every time I communicate with my classmates, and I get a bit anxious. But after the conversation, I feel somewhat happy that I was able to communicate with them in English, even though there were some stutters. When I invited him, I thought he would refuse, but he agreed quickly, which made me quite happy.

**P4:** It was positive. I could say it was positive, but not really strong. Like we're casually saying hello, but I couldn't feel any urgency from this kind of signal. So sometimes I really cared about her signal, although sometimes I did not.

8. How did the CloudPlanter influence your relationship or communication with your partner? Do you think you communicated more often with your partner because of the CloudPlanter?

   **P3:** Yes, actually it's my own thinking that gets affected because I feel like we have a common connection with him, so I can naturally engage in more communication with him. This connection will always be in my mind, and then I'll also understand his personality. But I think he's a bit aloof; he's very friendly when you talk face-to-face, but online he seems very distant and doesn't reply much to messages. I don't know if it's because he doesn't use the app we communicate with much.

   **P4:** So having the plant itself in my room was really great. Those green bars were amazing, but I think there should be something more to make our conversation more diverse and colourful. I'm hoping for more interactions, more diverse interactions. There could be some kind of smiley images, because I think these green bars are made with pixels. If you can make a pixel, you can make emotional faces with pixels. And it'd be great if you can enable us to express our emotions through this device to each other.

9. Do you feel you are more connected to your partner while you are using the CloudPlanter in this experiment? Why or why not?

   **P3:** Yes, because there's an additional topic, but I feel like I'm mainly reminding him of things, like when he can water the plants or something. I feel like I send long texts, and he just replies with three words, which makes me hesitant to ask about other things. I'm afraid of disturbing him because I don't know what time he goes to bed at night.

   **P4:** Yeah, but like I told you, not really much. Maybe if I had more time, then it could improve more.

10. Did your partner expressed that your partner had the feeling of increasing communication with you after joining the experiment?

   **P3:** No.

**P4:** Um, I'm not really sure whether it's because of this plant or not, but surely we are having more conversations than before in the studio.

## D. Evaluation

1. Would you like to use the CloudPlanter in the future? What improvements would you suggest for the CloudPlanter and why?

   **P3:** Actually, I think I would use it even if it wasn't connected to another person. I feel that the module could be integrated into the pot itself because as it is, it feels like two separate things. To me, this device is just a box that's attached to the pot. It's fine on its own, but I wish it would allow me to set a sleep time, and then it would automatically dim during those hours. I hope that when I approach it, it would sense my presence and flash or do something to let me know it sees me coming, just to have that kind of feeling.

   **P4:** I like the green bar function, telling me when to water the plant. But I would buy it when those kinds of interactions become more diverse, like if those things were improved.

2. Based on your participation in this experiment, how do you think IoT products can influence people's emotional experiences in the future?

   **P3:** Emotionally, sometimes when I feel bored, I engage in conversations with these products, like chatting with the voice assistant on my phone. I think to some extent, it compensates for the disconnection I feel in communication with people, and it makes my mood better. Because I feel that communication with people can be facilitated through objects, and with these smart products I've encountered, I feel they improve my emotional state.

   **P4:** Because I'm also interested in IoT products. I told you I'm really interested in social robots, those in the home. I think it will affect individuals' lives a lot, because in Korea young people are not trying to marry and they prefer to live alone. If this kind of trend keeps going, people living alone would feel loneliness. And it'd be great to have this kind of IoT device in your home. So you can make some kind of interactions with IoT devices, even though you don't have to go outside. And that is exactly the reason why I would be happy to see this device have more emotional expression and interaction functions.

3. Reflecting on your experience with the CloudPlanter, how do you envision the future relationship between humans and connected IoT products?

**P3:** I would definitely welcome more of these products, but I hope it won't be overly complicated. Simple operations like pressing a button are fine, but if it's not clear, users won't know what to do and will miss out on that part of the experience and data perception. If smart devices become too complex, people need to learn a pattern beforehand and then use it. I think there's a learning cost involved.

**P4:** I think humans need a companion in their life. And this kind of IoT could become one of those companions and also work as a secretary. Because in the UK people used to work in their home, rather than going to their companies. So it'd be more helpful to have this kind of IoT device to help you throughout daily life. But IoT products cannot fully replace pets and families, because we enjoy having those kinds of pets, for example, because they sometimes show unpredictable motions, especially cats. And because these kinds of IoT devices are really systemised, I think we can't really expect those unpredictable moments from them. That's why we still can't expect the same kind of thing we get from pets or families.

4. Do you agree that IoT products will promote the communication and shorten the distance between users? Why?

**P3:** I feel it would only have a minor impact, not a significant one. Because actually, I don't pay much attention to online platforms like WeChat or other communication apps. If someone asks me something and it's important, then I will respond.

**P4:** Yeah, because I'm the person who doesn't make contact that much. So it would have been really difficult for me to do this kind of experiment. But still, I managed to do all kinds of interactions. So I believe this kind of product would help people shorten their distances and make them closer to each other, because it has also worked for me. If you put more functions into this device, then people don't necessarily need to make personal contact and meet each other. But if you put only a really small amount of functions into the planter, then people will not buy the plant at all. So I think it is important to keep the balance.

## Interviews of P5 and P6 (Two former colleagues who are close friend but no long see each other quite often)

### A. Setting up

1. Where have you placed the CloudPlanter in your home? Could you describe the lighting and humidity of the environment?

**P5:** I placed it close to a window, and it's next to another plant. So it's on a little coffee table in my room. There's a lot of light because my room was originally a living room. So there's a lot of light sources. And the humidity, I wouldn't know. I would say it's okay. It's close to the windows so it's not too humid.

**P6:** It's on my desk in the far corner, about one and a half metres from my bed. It's in a position where I could see it every day, but not directly if I was sitting on the bed, because the light is pretty strong. When I'm sleeping, I don't want to see light. I have sort of a shelf turned towards the plant, so I don't see the light. I have one of those little things to measure the humidity. Now it's off though, because I ran out of battery. But I didn't change anything. It was almost always about 60% or 65%. The light comes from an east-facing window. I got some direct light in the morning, but I'm asleep then, so it doesn't really get direct sunlight. Halfway through the experiment, I put some grow lights on my other plants, which are about a metre away from your plant. I think it got a little bit of that, but it's irrelevant because of the distance. I didn't want to read too much into it. If I'm checking the soil now, it's still pretty wet, so I couldn't water it because it wasn't drying out. And to be honest, I didn't really interact with the plant that much. But I have to say, I enjoyed pressing the button.

2. Have you had to move it for any reason, and if so, when did that happen? Why?

**P5:** No, I didn't have to move it.

**P6:** No, I always kept it there. I lifted it just to clean, but I didn't move it. It was always in the same place. Yeah, maybe I moved it once, about 50 centimetres or a metre away because I was cleaning. Then I put it back. Did you notice that as well?

3. Did you encounter any issues the first time you connected the CloudPlanter to the Wi-Fi at your residence?

**P5:** No, I didn't. It was super easy for me.

**P6:** I kind of didn't understand at first because I had to connect it with the Wi-Fi. But I realised that if my phone was connected only to that device, then I couldn't connect it to my Wi-Fi at the same time. I was trying to understand that. But it was a matter with my phone, not the device. I didn't really know that option existed on my phone, the configure option. I mean, your setup workflow was pretty clear anyway. You did it on iPhone, right? Because I'm Android, I'm not familiar with Apple. So I thought that was something you could do on iPhone but not on Android. I managed to do it—I was talking to P5, and then at one point, I figured it out. At the beginning, I was a little confused, but it didn't take me too long. I just made it, I connected it.

4. Did you find encounter any issues in understanding how to interact with the CloudPlanter?

**P5:** Reading the instruction was extremely easy to understand.

**P6:** The interaction was pretty easy, to be honest. It's very simple the way you put it. I didn't really understand why it was a ladder instead of just like a battery pack. I mean, you have it going up like that, but this part is useless at that point, because then it's never on. That's a signal I relate to phones, but I'm talking about plants here. So I guess the semiotics might not need to change completely but adapt a bit more to my relationship with the plant. Stupid thing to think about maybe, but like—you could have a full leaf or a dry leaf, compared to a signal bar. That phone thing, I have it on my phone but I don't even look at it. To be honest, I remember looking at that when I had the Nokia 3310, the brick basically. On my current phone, I have the Wi-Fi bar, but I just expect my phone to work even if it doesn't have much data—it's 2020, so I don't look at it that much. That's why I don't feel like it should be like a phone thing. It should be more like—there's water. If you gave me three droplets, maybe five droplets that slowly empty, I'd get it. I feel like I'd want to see something full when it's full of water, then gradually going down. Also, if P5 left, I was thinking, okay, how does she know that? That's another issue, because this thing collects water from around it. So how do I know if the water here is fine, but on the other side of the pot it's not? This kind of thing—I don't know how relevant it is, because this kind of system is used in agriculture too. That's just me being picky.

## B. Personal feeling

1. How often did you water your plant, and what factors influenced your decision to do so?

   **P5:** I didn't water it. The entire time, the moisture was showing maximum. But I touched it, and I still felt like it was moist. So I didn't want to water it. But if I didn't have the CloudPlanter, I would have watered it. If you asked me about my intuition, I would have thought maybe I need to water it. But actually, it was pretty fine.

   **P6:** I didn't water the plant at all. I touched the soil as well. I work with plants, so I'm a bit more knowledgeable than some other people in terms of how to check what the needs are. So I was focusing more on the relationship with the plant. Having the plant with this tool gave me the relationship with P5. I was touching the soil because I was looking at the light, and I was like, "is it possible it didn't dry out yet?" So that's why I was always a little bit confused. I trust the sensor, but I trust my finger more. I work in a plant shop and I make terrariums. And as a designer, I specialise in the relationship between plants and humans. Oh yeah, that's why I love your experiment. Also, one thing—the light wasn't moving that much. I didn't see many changes. And that's why I was like, okay, is this working? Let me check the soil because I wasn't sure if it was working.

2. How many times did you checking your partner's soil moisture? What is your emotional response after checking the soil moisture in your partner's CloudPlanter?

   **P5:** I think four or five times. I think it was nice, because then I would just like text him. We're kind of like best friends. The emotional response was that I feel like I'm kind of of like spying. I'm seeing something that they wouldn't usually know. It's fun. There's something fun about it.

   **P6:** I feel like I missed one or two days, because I knew she had enough water. But I was checking it at least a couple of times a day, sometimes two or three times. Just because I wanted the effect, like if I pressed it, I could interact with that. I would send her a message and tell her. Yesterday I remember, she told me that the experiment is done and then I press the button, and I saw that she didn't have water. So I texted her. I was like: "oh shame!" She told me that she deactivated it. It kind of of gave me happiness because I could send a message about that. I guess the moment I'm about to press it, I'm expecting to have bad feedback, so I have an opportunity to text. The moment I press it and I see that she has a lot of water, I'm a little bit sad because I don't have an excuse. So if I have this thing, then I want to have a reason. I mean, sometimes I was texting anyway, like "Hey, did you water your plant already?" They definitely made me feel like with this thing I'm connecting with P5.

3. Thinking back over the past week, how much did you enjoy using the CloudPlanter? Could you explain why?

**P5:** I think the part that was the fun, the nicest thing is that I could be there for my friend. Because he's working and I'm having a lot of my master's coursework, we don't have too much time to catch up. Because of the plant, I feel like we talked more. Like he would tell me, "oh, I saw this on your plant today," or "this happened." So he'll tell you during the interview, but he struggled with setting up the CloudPlanter. He called me saying, "I cannot put it in, it's difficult," and then I helped him.

**P6:** It didn't give me any tactile satisfaction or visual satisfaction because it wasn't changing that much. So there wasn't much I could do. I could just press the button. At the beginning, I was looking at it like, oh, that's an interesting thing. Then it lost its interest. It doesn't need me much, that's the point. It checked my soil. But I wouldn't have it because I want to know the soil humidity. I'd have it because I want to look at P5's soil humidity. So I could connect with that, press the button, and be like "I'm in her life now." If I don't, it's just that. Beside pressing the button and waiting for an input from P5, there's not much I can do. If it was like a measurement tool, maybe it's just a graphic. If I close my eyes and imagine it briefly as something I want to look at, then I have the plant. I don't want it to be prettier than the plant. Otherwise, I'll look at that thing rather than the plant. That could disconnect me from the plant and connect me to P5. So I guess in a way, if I purchased this tool, the first reason would be to have it together with another plant that P5 gave me, so we could be together. I even mentioned to two friends—one in the UK and one in the States—that if they exchanged these plants, they could compete with each other. Then I'd want to take care of it a little bit more. And I'd feel the social pressure, thinking P5 knows if I'm taking care of the plant or not. So in that case, I would treat the plant a little bit better, because she knows that I'm doing that. If it was just my plant, I'd leave it there. And she'd text me like, "Hey man, you didn't go to the plant?" And I'd be like, "oh yeah." Maybe I don't like it that much. Different kind of thing.

4. Could you share some of the most pleasurable moments you had with the CloudPlanter? What does pleasure mean to you in this context, and what do you think triggered these pleasurable moments?

**P5:** The first time when I met P6 for drinks to give him the plant. Yeah. And I think setting it up was fun. Then you had a moment where I was checking his moisture level and talking with P6 about it. That was fun. I think there's something intriguing, like it's going to be connected to my phone and I'll be able to also spy on what we're doing. And at the same time, I'm also able to connect with someone external. So it's kind of creating this extra connection, like meeting with P6 also. I can see his, and he can see mine. One thing that I also liked was counting the layers when you water it. I wanted to see the light. But I didn't water it because I thought, "there's no point of me watering it just to water it." But the interaction is fun with the lighting.

**P6:** At the beginning, because it was a new thing. We had to set it up and test it. We were waiting for it to work in a particular way. At the beginning, that was new. But then slowly it kind of disappeared because I knew she wasn't watering the plant for a long time. So there wasn't much expectation for me. Also, the display wasn't changing at all. Not much visual impact for me to care about it long term.

5. Have you ever grown plants at home using traditional planters? Do you find that using the CloudPlanter is more pleasurable compared to those traditional planters? Why?

**P5:** Okay, so one thing I would say is, the only tricky part is that the light is always on. At night, I had to put something to hide it. But other than that, I think it was relaxing, because then I didn't have to worry about watering my plants. I just knew the entire week the moisture was fine. My other plants at home—some of them are super good, some of them are just kind of dying. And I don't know why. I try to water, but then maybe I shouldn't water.

**P6:** No. I know the ceramic ones and metal ones, and ones with automatic watering systems. I saw the ones with a storage inside where you water through a hole, and then there's a red thing that goes up and down when you water it. I really like that one. This one is much different. I wouldn't value it the same as a planter, because it's not a planter, it's just a device attached. I'd want it to be a little less obvious that it's a technological device. Because I don't want to relate plants with technology, with high tech. So fewer screens maybe? Not touchable technology. For example, instead of giving me a display with lights, imagine pumps—pumps when they grow and expand. If instead of a display, it gave me something that goes up with water, and then goes down when it needs water, I'd like that more. I wouldn't want to see a display on the outside. When I choose pots, I look at the plant and then choose the pot relative to it. If the plant looks messy, then get a simple pot. If the plant is simple, then get a messy pot. The outside shouldn't look technological—the inside can, but not with a display. I did research on another project, and apparently when people see a lot of technology in nature, it feels too contrasting, too sci-fi. So we should adopt it in a more organic way. Not just the shape, but the concept. So basically fewer screens. I'd get rid of the screen. I'd do it another way. The concept of connecting to another person—that's much more pleasurable, because it gives me one more reason to get pots. Let's say, for example, I'm a granddad stuck in my house, and all my nephews have these things. Maybe I give it to them, so I feel less alone. I would love that. If they press the button, I get the signal. Because then I'd be sitting on my sofa with the plant next to my TV, and as I'm watching TV I'd see James pressed the button, so he's thinking about me. I'd feel less lonely. Or somebody in a hospital.

6. What was the least pleasurable part of using the CloudPlanter for you? Would you mind sharing why?

**P5:** The least one was the light. That was the one.

**P6:** So I was a bit hostile on that. And the fact that it didn't change much. That made it boring a little bit. The screen or the shape of it, because it's a box. And probably the fact that I need to keep it connected to electricity constantly. I'm very clumsy, so if I touched the cable, I was afraid the plant would fall on the floor, and I have a carpet. So I was a bit hostile about that. And the fact that it didn't change much—that made it a bit boring.

## C. Partner

1. How far is your partner's residence from your place?

**P5:** He's in Kings Cross, I am in West Kensington. So we have like seven kilometres.

**P6:** It's pretty far. It's probably west London. About 45 minutes on the tube.

2. In average, how many times did you contact your partner per week?

   **P5:** Maybe like once a week.

   **P6:** Before we were seeing each other once a month.

3. In average, how many times did you contact your partner per month?

   **P5:** Oh, like much more maybe in person we will meet maybe like three times a month. Okay, because we're super busy.

   **P6:** So she went to uni, I was working. Probably even less than once a month, maybe once every two months or something. By text, probably three, four times max.

4. How many times did you contact and meet each other during the experiment?

   **P5:** A lot. We spoke every day on the phone, I think. And we saw each other three times in a week. So that's pretty good. A few days before we would text almost every day but just one or two messages. During the experiment, 24th, then 25th, 26th, 27th, and Tuesday which was the 28th. Every day.

   **P6:** We met in person once, because of commitments we couldn't really see much. But we texted each other.

5. How many times did you notice your partner watering his/her plant through the animation displayed on your CloudPlanter?

   **P5:** No, I didn't notice…

   **P6:** I was waiting for it. I was sending a text like "hey, did you water it?" "Are you gonna water it?" I never saw the animation. She told me that she watered it but I never ever saw it. Probably because I was at work. One thing you could do—if I press the button and she waters it, the first thing I should see is the animation. Because I didn't see it. I guess the animation comes from my device while she's watering it. She watered it on the 28th, she told me.

6. Can you tell me about how many times you've spoken with your partner about the CloudPlanter and the plant? What topics came up in those conversations?

   **P5:** So recently, we spoke about the plant, obviously. But we also spoke about his life. And I didn't realise he was going through a really tough period, but if it wasn't for the plant, I would not have known. So that's why we spoke every day, because I was trying to support him through the difficult moments of his life. He told me it made him really happy that we were sharing the experiment, because then he could feel relaxed, like he could rely on me. We also spoke about uni, projects, and about my personal life.

   **P6:** I feel like it was mostly about the water and about the experience. I wrote something like "I still hope my room doesn't catch fire because of the device." And then we were like, "okay, let's go for drinks out." We said it was fun to press the button. And because we chatted, it was mainly project-related stuff. We're friends, not a couple. So if we talk, we want to meet outside. She told me that she was going to Paris. We were talking about the project during the experiment.

7. What is your emotional response after having a conversation with your partner triggered by the CloudPlanter?

   **P5:** I think it felt really nice. Like, it makes me feel happy. It's my emotional response, I think. But also, I felt like you brought us back to our friendship, made it a bit more stronger.

   **P6:** Happy. Because I could speak to her, I had one more reason to speak to her. And it was simple because I had that as a topic of conversation. So the conversation could flow. I don't remember exactly what we were saying, but I felt like I had one more reason to text her or to speak to her in general because of that. That made it easier to talk.

8. How did the CloudPlanter influence your relationship or communication with your partner? Do you think you communicated more often with your partner because of the CloudPlanter?

**P5:** I think positively. I think it gave us more opportunities to talk, like it gave us more reasons to reach out to each other. Because sometimes I might have forgotten to reach out. The CloudPlanter reminded me to. It's not that I don't want to reach out. I do want to but I'm so busy, I forget. We've known each other for like three years or something. We met in my undergraduate.

**P6:** Yeah, I feel like because we were doing something together. This experiment was sharing a moment, sharing a device, and sharing thoughts in a way. I feel like I'm a bit closer to her now because of this. I mean, we were close before, but recently it felt like we were getting a bit distant. Because I left for a month, and she was here. She was studying and I was working. So we started feeling like life was getting much different. With this thing, we kind of got back together, even if we have different lives, we could still meet each other.

9. Do you feel you are more connected to your partner while you are using the CloudPlanter in this experiment? Why or why not?

**P5:** Yeah, I think so too. I think it made me more connected. But as I said before, it's like a reminder that this friend is someone that is still around, like you need to keep in contact in touch, even though times where he feels like so busy.

**P6:** Much more, very much more connected.

10. Did your partner expressed that your partner had the feeling of increasing communication with you after joining the experiment?

**P5:** He didn't tell me, but I think we both noticed that it was part of it, probably.

**P6:** I don't remember to be honest. I feel like she did, but it didn't happen many times. One time she told me something like, you know, we kinda… I don't even remember too much. Because when we talk, we just start talking a lot.

## D. Evaluation

1. Would you like to use the CloudPlanter in the future? What improvements would you suggest for the CloudPlanter and why?

**P5:** Yeah, I think it's useful. It made me feel like I don't need to check my plants. The cloud is gonna tell me if I need to water them or not. I think you need to have a switch to turn the light on and off, so you can put it in your room if you want. Maybe something where you can visualize each other—that's just a suggestion. I think that could be fun. You can see the other person's moisture, but since you have this little square, you could also send the other person a message. Obviously, I'm not gonna observe the other person whenever they water their thing. But it could be fun to connect a bit more, because in the long run, if I had this product all the time… like now it made me connect to P6, but maybe it's just for a weekend, and after we kind of forget about the plant at some point. To avoid that, to get a bit deeper, you could have this thing where you choose to send a little emoji or a little animation to the screen. Then the person receives it when they touch the button, and when they go home, they see this little animation on their plant. That could really connect you a bit more, like a reminder that the other person thinks of you.

**P6:** Yeah, for different people, like my mom and dad, probably my sister. The display—I would change it for two reasons. One is personal: I just like when it's something different from screens. The second reason is what I told you before: a lot of people want to see nature with nature. Too much contrast doesn't feel good. It feels like it's not right to have a screen next to a plant. Also, the shape—it's a box, and it's popping out of the pot. I think it shouldn't be popping out, because otherwise I can't put two next to each other. Then the cable—if we could find another way, that would be better. And the button—I feel like it could be a little more playful. Not like a stress relief thing, but I should want to press the button for fun. In that way, the other person will notice the input more. Otherwise, it's just me having to think about the person and choosing to go press the button to show I'm thinking about them. And a lot of people are very much into themselves, so maybe they don't think this is a big thing. If the interaction point was more interesting and tactile, like the texture, the shape, maybe it flexes, maybe it rolls, something pleasant to touch. I think that's one of the most important things besides the screen. And as I said, I want to notice when she pressed the button. If I press the button and she waters the plant while I'm not there, I want to know on the same day that she watered the plant. If I press, the first thing I should see is the indicator going up, then the condition of the water. If it needs to be a screen, maybe it could get larger or smaller, move a little, or change color. Something not as bright, something that feels more natural. And you almost got it here, because that's exactly what I'd do: having the surface constant with light behind it to light it up, but less bright. So, just to be clear: no cable; the light is too bright; the button needs to be more tactile; the overall shape needs to hide more, pop out less; and I want to notice the input when she presses the button.

2. Based on your participation in this experiment, how do you think IoT products can influence people's emotional experiences in the future?

   **P5:** Yeah, I think they can, but it depends how you build the experience around it. You need to have something seamless, easy to use, otherwise it won't be feasible. But you also need something that sensitises you to the product.

   **P6:** I think with this experiment, we could feel more connected through technology. I like it because it applies to plants. I use another living organism to feel connected through a device. It makes sense, because I'm using plants connected to me. The only problem starts when the device violates my privacy. At the beginning, I was joking, like: what if you put a microphone in it and listen to our conversations? That's wrong. I wouldn't want IoT to know more than I want it to know. So in this case, the design works well. But in general, IoT could be good or bad. Good—for example, Citymapper understands me, it tells me exactly when the bus is coming because other people on the bus are using the app. That's like a decentralized brain, and it works. But I wouldn't want my camera to talk to my computer, and then I talk about horses, and suddenly my computer shows me horses. Or I take pictures of red flowers, and then my computer shows me red flowers to buy. That's too much—it messes with me. I like communication between devices when I am the one communicating. But I don't like when devices communicate with each other to serve a business using my data. I should be in control of myself and my life.

3. Reflecting on your experience with the CloudPlanter, how do you envision the future relationship between humans and connected IoT products?

   **P5:** I think you can build a better relationship. So if IoT products enhance, with the CloudPlanter, I feel like it enhances my possibility to actually view how my plant feels in a way. Because even if the plant doesn't have feelings, I could see its moisture level, so I could care more for my plant—better than if I do it with my hands when I test it. It can improve how I take care of my environment and my surroundings. In a way, it's kind of like allowing me to have a tool that makes me take care with a measurement. It's not me guessing anymore if I'm taking care. It's more like measuring the amount of care that I need to have for the plants. So I think that's how in the future I see those tools being useful to actually help us be more careful about the actions that we're doing, and the amount of things that we're using. Let's say, for example, I was thinking about what you were saying also, about the layer of whether or not. I think intuitively, if you don't have these tools, you might actually think that you're caring for your plant, but you're actually overwatering it. IoT will be a tool that really helps you measure things and have scalability. So you have more—it's going to be more like qualitative, right? In terms of refining this kind of scalability. And then for the relationship with people, I guess you kind of associate, like with the plants, because of my association with P6. There is something really nice. Because the IoT allows me to take care of my plant, but the plant is also connected to this other person. There is a dual function, where my brain ultimately associates my relationship with my friend with taking care of a plant, but also it benefits me. So then I feel more like I get feedback from a plant that obviously it's not talking to me, but it's allowing communication in a different form. So I think there's a future where we're going to be able to translate a certain amount of rain, for example, into some kind of messages, like maybe this becomes a new way of translating.

**P6:** I think because we have AI. Besides the climate emergency—that's a bit more of a trend at this point. It's all about AI, technology, IoT, with Musk basically. And I feel like people will become a little bit too dependent on that. It's not necessarily bad if, in our economy, we are allowed to use technology to make money. But if I still need to go to work, I need to stress over money and everything about my survival. And I have all these IoT devices powered by AI, businesses using it as much as they can. I think people will feel a bit too intimidated by that. Technology is good, but not this much, and we cannot do our lives without it. But if IoT devices combined with AI, combined with big data and analogy, serve each person individually or in groups, it will be easier for us to live, for us to survive. I'm imagining the IoT device of the future will be so clever that it is a robot. A robot is an IoT device. And I feel like there will be detachment between the two organisms, which are humankind and a robot, or IoT or AI. Because they will be able to do a lot of things and they will also communicate between each other in a moment. And then we have quantum computers as well. It's even worse. We will become like monkeys compared to them. In a far future, I guess we will be the chimpanzees, and they will be the humans in a way, if I don't understand that technology, IoT technology. Combined with the rest of it, I think IoT is good. But it's like an empty box that can connect and communicate with other boxes. Used well, it is useful, but it doesn't have a soul. The moment you put high tech in it, it becomes a little bit more like something I don't really understand. Maybe the faster human beings—because it's like human beings with a telepathic power. So how do you compete with that? You can't compete. So the whole world is feeling a little bit more unsure to me. Maybe I'm just speculating, but I guess in that way also we get addicted very easily. So we first start using this device over and over again for years, and then something happens—it doesn't work anymore. I would be feeling a little bit stressed out, because I'll be like: oh, now I have to find another way to connect to a plant, to friends. And if I'm used to that—because this technology kind of makes the job a little bit easier for me to stay connected with my friends—if I abuse it, is that actually going to hurt me or not? I don't want to disturb because I really like the project, but overusing technology has shown us to be less adapted to the real world.

4. Do you agree that IoT products will promote the communication and shorten the distance between users? Why?

**P5:** Yeah, of course. I mean, obviously, with your phone nowadays, it brings you closer to everyone. So there's definitely that aspect where it does. But you need to be careful, because if you rely too much on technology and you think that being close to someone is only speaking on the phone, then that's also another issue. Like us, we need to remember that the first point of contact is in person. And that's where the IoT can become something that replaces this gap of me not seeing you. If I start valuing more the CloudPlanter, I don't think that, in terms of my connection with P6, I don't think there's value in me meeting P6 anymore, because I can still see his activity on some kind of IoT device. That's where I think the limit of IoT products is, it makes us believe too much. We have the visibility of another person just being on the device, and we're not caring anymore about the in-person relation. And if you get used to that too much, like you see already nowadays, young people think they don't need to meet in person because they've already been on their phone with the person. But that's actually not valuable. That's why I think you need to be careful about how much you're offering the person.

**P6:** It depends on the context. If you end up in the same conclusion, because if I physically cannot connect much with the person and they make it easy, that's really useful. Especially if somebody is about to die, for example, and I'm at work, I want to bring this thing around me. So every time that I see this thing beeping, it's maybe my dad on the bed in the hospital. But if it's classmates, I didn't like all my classmates. And I had a friend of mine, she talked for hours, more than P5 and I. Imagine, I wouldn't want to be constantly connected with them. Yeah. I'm afraid it will become a social obligation if it becomes mainstream. And if you put it in the context of everybody can use it or everybody should use it, I don't think everybody should. I think the people that are distant or are having restrictions should be using it. They have to, because it regenerates and makes you feel more human in a way, because you're connected in your mind. But not if it becomes something you have to do. It's like messages. I remember with Instagram, now, if people have a fight, like they argue about something, they get upset with each other, they unfollow them. For instance, I find that too stupid, to be honest. In this case, it works. So there's a lot of potential in that; it just needs to be used in the right context. I don't think it's feasible either. Because if you think about the army, a lot of the technologies that were meant to be used for good ended up being used for bad.

## Interviews of P7 and P8 (Partners)

### A. Setting up

1. Where have you placed *the CloudPlanter* in your home? Could you describe the lighting and humidity of the environment?

   **P7:** Initially, I placed it on the windowsill in my bedroom, but later, due to poor network connectivity, I moved it next to the router on the ground floor. If it were in my room, the humidity might be a bit lower because there's no heating in my room. However, since both places are actually shaded, there shouldn't be too much difference in terms of light. Downstairs, as it's in a more public area near the entrance, there's no heating, so theoretically, it should be a bit more humid there. That's probably why I haven't watered my plant until now, or maybe just once, as far as I remember.

   **P8:** On the window. The window obviously gets sunlight during the day, daylight for most of the day, and in the evening, light from the main set of room lights. I wouldn't be able to determine the humidity, because you'd need some sort of device to measure it. I would say it's average.

2. Have you had to move it for any reason, and if so, when did that happen? Why?

   **P7:** Due to poor network connectivity, I moved it next to the router on the ground floor.

   **P8:** Yes. Because of the LED lights, which are extremely bright. it was initially in my bedroom, and I needed to move it into the hallway.

3. Did you encounter any issues the first time you connected the CloudPlanter to the Wi-Fi at your residence?

   **P7:** No, I think it's quite easy. The CloudPlanter was disconnected to the WiFi few times. It's probably because I moved it next to the router, which is located right at the entrance. Recently, we've been renovating the kitchen, so there might be a lot of workers moving things in and out, and they might also place some idle items there, which could bump into it. Especially since our router downstairs only has one socket, which isn't enough, I brought my own power strip from home. My power strip is actually from back home, and I don't know if using it might cause some adverse reactions. I even changed the power strip once. The reason I initially used one from back home is that the sockets here in the UK are very close together, and the UK plugs are quite large, making it difficult to plug two things in at once. Later, I switched back to a UK one because I was worried that the one from home, which might only have two prongs, could be unstable or something.

**P8:** I personally haven't encountered any issues, but I think the device has intermittently disconnected from the internet. Well, it's just that we generally have quite bad Wi-Fi here. So even though it was next to the Wi-Fi router, I think it's still been affected. Generally speaking, over the past 10 times, the internet has gotten worse, obviously because a lot more users are using it.

4. Did you find encounter any issues in understanding how to interact with the CloudPlanter?

   **P7:** Sometimes when I press the pattern, my partner's data doesn't immediately appear, but I'm not sure if this is due to a delay in response time or because we're often not online at the same time. It would display eventually, though. And on my partner's side, the level hasn't been much change; it's always seemed like there's a lack of moisture.

   **P8:** At current stage it's pretty simple. I would say there's almost very little interaction in general. To build a study, and there's a really easy instructions to interact with it. It's just pretty simple and straightforward.

## B. Personal feeling

1. How often did you water your plant, and what factors influenced your decision to do so?

   **P7:** I think I watered it once or twice. I've actually forgotten. The reason I watered it was probably because the humidity dropped, or the display showed it wasn't enough, so I would water it. I'm actually a bit obsessive-compulsive; before, when I couldn't see the humidity level, I also kept plants and often forgot to water them or something, and they would die. But now that I can see the moisture level, I feel the urge to water it as soon as it drops even a little.

**P8:** In general, given that it's winter, you only need to water a plant about once a week. Over two weeks in my place, I only watered it twice. So I think for that sort of experiment, obviously watering is not the subject of the experiment. It's more about a connection between two plant users. I haven't watered it that much, which obviously impacts the amount of interaction. I interacted when I first put it in the room, but it was too bright, so I moved it to the hallway. After that, I only came down to interact with it twice in the span of two weeks. So there wasn't much interaction happening. I generally just know that I need to water it once on the weekend. And obviously, the LED light indicates low levels of water in the soil, but to be honest, they never dropped to extreme levels. It was P7 who called me up and said, "Did you water your plant?"

2. How many times did you checking your partner's soil moisture? What is your emotional response after checking the soil moisture in your partner's CloudPlanter?

   **P7:** Every time I told him to go online or to unplug and replug the device, I would check, and often there was no change on his side, so I thought for a while that his device was broken. Actually, this matter is somewhat concerning to me, and I've been reflecting on myself. I wonder why I get so angry every time I tell him to water it and he doesn't. And earlier, when I asked him to unplug and re-plug, he said he did, but there was never any change on my end. I always thought there would be some change, and I got really angry, feeling like he was fooling me, saying he unplugged it when he actually hadn't, which made me very angry.

   **P8:** To start, I'm not a big plant person. So I have very neutral feelings about it. Given the current conditions, as I mentioned, you can literally water once every two weeks. Depending on the species of the flower, it might even be less than that. So I've seen that there's no danger to the flower itself, even if I don't water it for two weeks. It will survive anyway and just recover. I don't think I have any strong feelings about it.

3. Thinking back over the past week, how much did you enjoy using the CloudPlanter? Could you explain why?

   **P7:** At first, I quite enjoyed it because I could see the soil moisture of my plant, and later, I could also see my partner's soil moisture levels and remind him to water his plants. But later on, especially after moving it downstairs, I didn't pay much attention to it because it was no longer in my sight. Also, I felt angry when

I thought my partner wasn't watering it, but I later realised I had misunderstood him. It turns out the place where he kept it was very dry. I personally saw him water it at his house, and the soil moisture level dropped quickly afterward. It might have been because it was placed right above a radiator. So, after realizing my misunderstanding, I wasn't angry anymore and just let it be.

**P8:** I'll be honest. I'm very specific about devices in general and in my life. And at the current stage, I don't particularly enjoy it. It's more of a nuisance for me, because I don't really need a device to remind me to water my plant. Since I'm not already a plant lover, and it's not something that I'm passionate about, I don't find much value in it. But I guess in circumstances where there are more plants and you have tons to look after, it might be useful. But again, I think your project is more about a connection between two plant users rather than just watering plants. I obviously would modify it in many ways, and you may have already thought about that. In the current iteration, it's just not engaging for me and more of a nuisance. Some people might find it differently, obviously, but I don't find it particularly engaging at this stage.

4. Could you share some of the most pleasurable moments you had with the CloudPlanter? What does pleasure mean to you in this context, and what do you think triggered these pleasurable moments?

**P7:** I asked him to water the plants, and then I saw the animation. I think it was when I called him and told him to water the plants, and then he did it. One point is that, to some extent, he did what I asked, which contradicted my previous assumption that he wouldn't do it. That's one point. Another point is that I saw something different from before, so I was actually quite curious about the animation and what it would be like. Maybe it's a bit of an obsession.

**P8:** No. I think if it would happen, essentially what I would do is, first of all, it would have a movement tracker. So as soon as you come to it, that's when it lights up. It doesn't light up again unless it needs watering or the other CloudPlanter user checks your water levels. That would be exciting because, for example, if you're sitting at home and then you have this plant somewhere in the window, as soon as someone else checks your water levels, perhaps you'd have some kind of emoji coming up on the LED screen rather than something very minimal. It doesn't need to be a proper LCD screen to show your emotions, but it could be more like magic, like 20 LEDs drawn into the panel. You'd have perhaps some sort of question mark or whatever coming up when someone is checking, and you'd be able to tell who is checking. So you'd be able to see, "someone is checking my water levels," and that would perhaps be more engaging. And also, once you have a movement sensor, which is super cheap and super simple to install on this kind of device. Every time you're passing by, it would perhaps wake up and then show: "do I need water or not?" Or maybe even an indication that tells you: "you need to water in 2 days" or "come back and water me," or some sort of emotion. So you could tell if it's at critical levels of moisture in the soil. It may have a crying emoji or something like that, and then you'd be like: "let's check the levels!" and then you'd go to the next step and check. And once you're checking levels, I think you should be able to see straight away the levels of your other CloudPlanter connections. So it would tell you not just your levels but someone else's as well. I think that would be a little better. I personally think, at the current stage, it's obviously a project, but you're probably looking into developing or adding to what you already have, or something similar.

5. Have you ever grown plants at home using traditional planters? Do you find that using the CloudPlanter is more pleasurable compared to those traditional planters? Why?

**P7:** I think it would, especially if every time you water the plants, it's not necessarily your partner doing it, but you yourself, and then there's some kind of feedback like "I've had enough water." You might feel like you've done something very fulfilling, especially for people like us who love to grow plants but often end up killing them.

**P8:** I think initially I would say no, because, as I mentioned before, I really think it's a nuisance at this current stage. But once it's going to be something—if you perhaps even make a pot that has the screen built in, rather than a separate device sticking out from the pot, which is probably very easy to implement anyway, then you would be able to make it more engaging and maybe more pleasant to look at. So the answer to the question is: I don't find it particularly engaging at this stage. It would probably need some decoration for me to really see the potential of engaging with it and spending my time on it, instead of just watering my plant once a week.

6. What was the least pleasurable part of using the CloudPlanter for you? Would you mind sharing why?

**P7:** The least pleasant aspects are one or two points. One is the stability of the network. Actually, both my friend and I have this problem. We don't know if it's because the home network sometimes might not be as good as a commercial one or something else, but sometimes his network is also very slow, and so is mine. We both might have this issue, but we don't know what the requirements for the network environment would be for the plant in the end. Another possible issue, of course, since it's a prototype, might be that the device can only be this way, but we both always felt it was too bright. Really, it's too bright, enough to completely illuminate the entire night.

**P8:** And at this stage right now, I don't think it's engaging. But looking forward, there's a lot of potential. For example, you could even have SMS messaging built into the Wi-Fi, so the device could remind you if you missed your watering. That would remind you to water your plants, and that could be an option. And then you can go on and on. You could make an app where you have a community of people using CloudPlanters.

**C. Partner**

1. How far is your partner's residence from your place?

   **P7:** Within 5 kilometres.

   **P8:** Not very far. I would say about 3 miles. Half an hour on Tube.

2. In average, how many times did you contact your partner per week?

   **P7:** We usually meet 1 to 2 times.

   **P8:** Every day.

3. In average, how many times did you contact your partner per month?

   **P7:** We both tend to be free on weekends, we definitely meet then. Sometimes, if we're free during the week, we'll meet once; if not, we won't meet during the week. It's just that kind of situation. Other times, like during holidays, we all get together.

**P8:** Pretty much every day.

4. How many times did you contact and meet each other during the experiment?

   **P7:** Probably quite a few times, because it's just about Christmas. We met for Christmas and have been together since then. We also met once before Christmas, and I counted that as one meeting, but then we met again in between. So yes, quite a few times, probably because it's just around Christmas.

   **P8:** I don't think we contact more often than before.

5. How many times did you notice your partner watering his/her plant through the animation displayed on your CloudPlanter?

   **P7:** Only once.

   **P8:** I haven't seen the animation actually. I think I only checked a couple of times. As I mentioned, this was too short of a time to really have enough data. I haven't actually seen the animation.

6. Can you tell me about how many times you've spoken with your partner about the CloudPlanter and the plant? What topics came up in those conversations?

   **P7:** The first time we both talked about how it was too bright. The second time, we mainly discussed the network issues, and then there was another time when it was quite apparent that I asked him to water the plants, and we talked about wanting to see the animation. Other than that, there don't seem to be any other topics.

   **P8:** A couple of times. Maybe 3 or 4. I'm generally interested in new products and product design. But generally speaking, we only had a few conversations, and they weren't very deep given the current iteration of the project. For me, it was more about thinking how it could be improved. That's why I mentioned a potential update to your device.

7. What is your emotional response after having a conversation with your partner triggered by the CloudPlanter?

**P7:** Generally, there aren't any emotional fluctuations; there was just one time I was very happy and then watered the plants.

**P8:** I don't know—very neutral, let's say.

8. How did the CloudPlanter influence your relationship or communication with your partner? Do you think you communicated more often with your partner because of the CloudPlanter?

   **P7:** There was a period when it affected me; I was very angry for a while. Yes, at that time, I was thinking that theoretically, your division is actually meant to bring two people closer, to create some common topics by co-caring for a plant. Although it's two plants, it instead became an opportunity to create friction. Like with my obsessive-compulsive tendencies, I'd think, 'Your plant needs watering, why haven't you watered it yet?' and then he would say he has watered it and it still hasn't improved. It definitely had negative effects at the beginning, but later on, they disappeared because as long as the misunderstanding is cleared up, there's no issue.

   **P8:** Again, it's too short. I think you probably would need something like a month to really see the impact. And perhaps it would be more engaging if, as I said, you even just had a simple emotion—like a smile coming up when the plant is watered, rather than just a blue light, or the plant displaying that it's crying rather than a red light. I think if you give it a bit of emotion, that would perhaps create a little more connection. At the moment, it's more like traffic lights: is it fine or is it not fine? And I'd say, again, very little impact at this stage.

9. Do you feel you are more connected to your partner while you are using the CloudPlanter in this experiment? Why or why not?

   **P7:** Not really. Both of us are in a situation where we chat every day, so it hasn't made our conversations more frequent. It might be because we are both still in a honeymoon phase, perhaps? So, two people who are in the honeymoon phase tend to have a higher frequency of communication and don't really feel much about it. Because the planter is downstairs. And also, the time was too short. Then, I guess if the time were longer and I could see some more noticeable growth changes in the plant, the connection might be stronger.

**P8:** I think in a way, because obviously, you are like literally connected, because there's a kind of separate parallel line. You could say so.

10. Did your partner expressed that your partner had the feeling of increasing communication with you after joining the experiment?

**P7:** I didn't ask him.

**P8:** I think it's almost negligible, because I wouldn't be able to tell whether it created more connection. We're already well connected and converse quite often. So I don't think the presence of the CloudPlanter made a massive impact at this stage.

**D. Evaluation**

1. Would you like to use the CloudPlanter in the future? What improvements would you suggest for the CloudPlanter and why?

**P7:** I think there could be more encouraging animations, like motivational animated feedback that provides more positive reinforcement. As mentioned earlier, for people like us who often end up killing plants or those who care for plants, they would definitely be happier if they could see the plant interacting with them after they've watered it.

**P8:** I'd say yes, if potential upgrades were implemented in this. At the current stage, as I'm personally interested in product design, I can see there's a lot of potential in this product. So going forward, it would be a cool present to give if it does display a lot—if it has more in it. With several iterations, even adding a movement sensor, it could light up only when you come closer to it rather than being on all the time. Because we already have a lot of distractions in life, and this is just an additional one. You'd want something that comes up suddenly when you come closer to it or when you're passing by, something that briefly reminds you of its existence and is more seamless in an environment rather than just being an annoyance. At the same time, it's a good start, because essentially the more it annoys you in your daily life, the more you think about how you could improve it. So for you, it's a lot more useful to have it at this sort of stage for testing it out, rather than already being a perfect product. Having it as a gift for someone might also be an interesting thing. And also, I would add solar. I wouldn't make it a separate device; I would make it a pot. It could be something like a low-grade LCD display, or a curved one, or just LEDs. There are a lot of variations you could put in: on one side you could have some graphics coming up, and on the other side mostly a solar panel, so it would feed the actual device itself. You wouldn't need to connect it to the plug. So one side would be solar panel charging the batteries for the main screen, and once you add a movement sensor, then you'd have an opportunity to create something incredible. It would be really cool to have a truly interactive pot for yourself. People could really connect with it, and given the pandemic, it would be the perfect time to launch this product. I think there's still a good opportunity, because apart from showing emotions, you can feed in more functions. Once it has a movement sensor, it could also detect whether there's a lot of movement in the room. Maybe it could even suggest you go for a walk with your CloudPlanter. I think giving it more human-like emotional responses, something a human can connect to immediately, would be powerful. For example, being able to see the plant about to cry, or something funny and awkward that grabs attention and brings you back. For me, if I had this project, I'd start with solar and a movement sensor, add a larger LED display, and build it into the pot. It's already connected to Wi-Fi, so you can connect between two pots. The hardest part is already done, pretty much. Then you can start working around that, trying to build a community, so people would be able to share pictures when their pot is super happy and their plant is actually thriving. I'd also create a library of different plants and how often they need to be watered, because you can't just use one humidity sensor for every plant. Some plants need drier soil, while others need more humidity. So that would obviously be part of setting up the CloudPlanter. I would even create a knob as well, and that would be absolutely awesome.

2. Based on your participation in this experiment, how do you think IoT products can influence people's emotional experiences in the future?

**P7:** I'm more inclined towards the emotional value. Perhaps it's about why people keep plants and animals; they might be looking for companionship and to build confidence, feeling capable of taking care of other things. They might think that if the device can provide a lot of positive and negative feedback, and if this feedback is more varied and not just the same animation every time they water it or the same routine, it would be like having an electronic pet.

**P8:** It's a never-ending battle, because we are constantly evolving as a society. Essentially, because of all those distractions in our lives, we're actually getting more depressed. But with each new iteration, we're living in an upgrade society where we're always trying to make things better. And when we get something slightly better, or when we notice a change, we kind of feel happier. So I think it's a very philosophical question, because we're essentially battling our boredom by introducing new things to distract us from suffering. Perhaps the plant will also be part of that—part of this ecosystem of devices that are trying to distract us from just "being there" without anything. Because literally 100 years ago, you didn't need a planter connected to your neighbour. But at the moment, the way we live in urban mega-cities, people don't connect with their neighbours. And perhaps this kind of device provides the opportunity to still have some sort of connection, a human touch to our surroundings, and a feeling of being connected. Before, it might have been a neighbour passing by your garden and thinking your plants looked terrible, telling you that you needed to water them. Then you'd go and sort out your tomatoes or whatever plants you had in your garden. But today, because we're living in boxes, I think this represents a slightly different angle on that aspect of life.

3. Reflecting on your experience with the CloudPlanter, how do you envision the future relationship between humans and connected IoT products?

**P7:** I already feel that the connection between people and smart products, smart homes, is already very tight. It's just that often people might not realize it. For instance, the widespread use of Alexa here, or the XiaoDu speakers in China, these are the simplest and most common household scenarios that are already quite prevalent. In the future, there will definitely be more and more of these, and they might even be interconnected within the same system.

**P8:** I think that perhaps repeat Elon Musk. At the very end, I think in the future, we will not need to work or do anything because everything will be done. But essentially like that's all these subjects will start doing things itself. Like, for example, if you eventually make a pot which will be showing some images and nice graphics and have a motion sensor, another iteration will be watering itself or something like or maybe extracting water from the air and then watering it. Your plant that will be like super smart pot, which will be able like almost sustainable live the life of its own. And you'll be just receiving like some sort of notifications where it just will maybe make you happier. So I I think it will be more automated.

But at this point, along with your particular project, you probably won't keep a certain level of engagement of the human. So you want them to come and do and things like that. So perhaps you want to encourage activity rather than opposite.

4. Do you agree that IoT products will promote the communication and shorten the distance between users? Why?

**P7:** I feel it's like when you're raising pets or children, and then suddenly two people start talking and discover they have something in common. It's in this aspect that it enhances the relationship, discovering that there are some interests we share, creating a topic. That's possible. But I find it hard to imagine that by taking care of plants, I might become more patient with people or more attentive to others' emotional expressions. I'm not quite sure about that. Because what each person learns or gains from it might be different. Maybe some people can be more patient, and some people can't.

**P8:** I think it might bring people closer, but in a sense, not physically closer. It might just make you feel more connected to them in some ways. I don't know. I don't really like the idea of this kind of future, because I don't think it really improves life. When I think about it, I feel like it's not a great ending for the world. In general, life should continue as it is. And even if it does make people more connected, maybe that's what we need—just something to make people feel less lonely.

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