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Evaluation of the usefulness of path of long-term user experience model in design process

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ABSTRACT

User experience evolves in accordance with users' attitudes, habits, and personality, as well as their prior experiences. Even though there are attempts to holistically frame the long-term experience of interactive products, there is still debate on how to guide designers in the design process of those products. To tackle this issue, this paper proposes the usage of *Path of Long-Term User Experience (PLUX)* model in design process. To interrogate the usefulness of the model, we conducted two studies. First, we adopted, adapted and tested the applicability of the *backcasting approach*, together with the visual materials that could be used in the design process. Following this, we tested the effectiveness of using the PLUX model as a guidance tool in designing interactive products. The PLUX model together with the backcasting approach helps designers to better ground their decisions in the design process and to find ways to enrich long-term user experience. The stages of user experience as well as the human and product-related qualities of the PLUX model facilitated in-depth reflection, and espoused creative interpretations of these qualities for ideation. However, the high level of detail is found limiting at times, depending on the ways the model is utilised.

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Interactive products; user experience; design for long-term experience; backcasting

1. Introduction

It has been more than a decade since Redström (2006) criticised the early models of experience through their shifting focus from 'designing objects' to 'designing users'. This led to discussions on understanding users better, and such discussions aimed to broaden the knowledge about users (Forlizzi, Disalvo, and Hanington 2003; Hassenzahl and Tractinsky 2006). Since then, several multidimensional models adopting various perspectives on how people experience particular systems, products, or technologies have been framed (Desmet and Hekkert 2007; Fokkinga et al. 2014; Hassenzahl 2008; Haug 2016; Karapanos et al. 2009; Mahut et al. 2018; Pucillo and Cascini 2014). While such models offer a generalised understanding of user experience, it has also been discussed that user experience is unique, dynamic, subjective and temporary (Hassenzahl and Tractinsky 2006; Karapanos et al. 2009; Karapanos et al. 2010; Mahlke 2007; Vermeeren et al. 2010). This aspect of user experience (UX) is what makes it complicated to measure, to understand the design constraints it presents (Law, van Schaik, and Roto 2014), and thus, to design products accordingly (Shin et al. 2017).

Experience-driven design (Hassenzahl et al. 2015; Hekkert, Mostert, and Stompff 2003) requires an understanding of how an interactive product is experienced and what users' expectations are (McCarthy and Wright 2004), through reflecting on the intended effects of technology. Studies in recent years showed that user experience has a dynamic nature. For instance, Karapanos et al. (2009) studied the temporality of the experience by defining the three phases of experience. Accordingly, the user gets used to the product in the first phase, begins to explore different properties of it in the second phase, and the product becomes part of everyday life in the last phase. The user finds ways of expressing himself through the product at the last stage of product use (Karapanos et al. 2009). Previously, Roto (2007), by highlighting the effects of user's pre-use expectations and perceptions on how a product is later used, suggested that the user's experience starts with 'pre-interaction' phase. The most important thing that

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Roto points outis that dynamics of a long-term and lasting experience should be investigated, rather than investigating the users' 'one-time experience' (Roto 2007). In that sense, there is a common ground on perceiving user experience as dynamically changing process, and assessing the intended effects of technology from this dynamic perspective (Kujala and Miron-Shatz 2015; Kujala et al. 2011; Vermeeren et al. 2010).

The late 2000s has seen an emphasis on the necessity of models and methods for holistic understanding, evaluation and improvement of experience (Hassenzahl 2008; Kort, Vermeeren, and Fokker 2007). The recent studies are focused more on investigating users' experiences with specific products and systems (Cruz Mendoza et al. 2015; Haug 2016; Kuru 2016; Michalco, Simonsen, and Hornbæk 2015; O'Brien 2016). A common understanding of what user experience is or should be is still distant (Hassenzahl et al. 2015; Law, van Schaik, and Roto 2014); the disagreement even makes it hard to decide whether we should design the experience or design for experience. Considering the discussions in the user experience literature, and reflecting on the criticisms of Redström (2006) on designing the user, in this paper, we seek an option to design for long-term user experience. Our aim is to propose a tool to design for long-term experience, without manipulating the overall experience of users, but by facilitating the richness of experience through defined product qualities. Therefore, in the following lines, we put forward the background of our argumentation and communicate our Path of Long-Term User Experience model.

2. Design for long-term user experience

Design is a stage-based, iterative, creative and complicated process (Green, Southee, and Boult 2014; Seitamaa-Hakkarainen and Hakkarainen 2000; Wahlström et al. 2016), at every stage of which the designer needs to tackle several challenges regarding both the product and the user (Hitchcock, Haines, and Elton 2004). The user-centred approach involves the end-users' insights into the design process (Säde 2001), and places the needs and expectations of users at the centre (Wilkinson, Walters, and Evans 2016). So far, there are already concrete and practical methods and principles that have been applied for user-centred design (van der Bijl-Brouwer and Dorst 2017).

In order to get the most effective input from users to the design process, users' experience and interaction should be explored in the early stages of the design process (Wilkinson and De Angeli 2014) by optimising the characteristics of the product deliberately (Giacomin 2014). While it is naturally impossible to force people to have a certain type of experience with technology, designers can aim at facilitating it (Wright, McCarthy, and Meekison 2003). That is they (should) design for an experience rather than trying to impose and design a pre-defined experience itself. A designer can only facilitate, not guarantee, a particular experience with products. The critical question of Verganti (2009) is relevant here: should we eliminate the free space for user interpretation or should we make a proposal to the user and let the user explore the experience through the artifacts we design?

It is clear that the characteristics of products affect the way people experience products which results in impact on people. This impact could be on emotions, attitudes or behaviours of users (Hassenzahl 2018). The human behaviour and the usage of technology are always interrelated; people's behaviours affect the way technology is used, while the capabilities of the technology affect the ways people behave (Slob and Verbeek 2006). Underexploring this reciprocal impact can lead to unintended changes in people's behaviours. However, the potential impact of an interactive product on people can be explored through its design. Experience of interactive products can result in change in people's behaviour (Lockton, Harrison, and Stanton 2010; Tromp and Hekkert 2016; van der Bijl-Brouwer and Dorst 2017). It is still not definite whether user experience research extends our understanding of how users experience interactive products. Therefore, designing for long-term user experience can be regarded as making predictions about the future use of artifacts (Pucillo and Cascini 2014). Designers can define several goals that a product can potentially achieve and design for intended experiences rather than concretising a particular experience (Kaasinen et al. 2015).

Considering the complexity of both user experience and design process, design for long-term user experience becomes even more challenging. While considering the user-related issues, user-centred approach can be followed from the very early stages of the design process with tools and techniques like personas and user journey maps (Han 2016; Hanington and Martin 2012). Yet designers still require inspirational sources for idea generation (Gonçalves, Cardoso, and Badke-Schaub 2014) and efficient ways to incorporate long-term user experience considerations in product development (Varsaluoma and Sahar 2014). In relation to the previous arguments, we agree with Verganti (2009) that, through products, the designer should present possibilities to users, by modelling the intended impact and being aware of the possible negative effects of usage, rather than forcing users toward one, predefined experience.

As such, we developed a tool for communicating the reciprocal relation between products and users, and the dynamic nature of this relation, detailed enough to be utilised in different stages of the design process (i.e. idea-generation and detailing). Our purpose was not to ensure a certain kind of experience but to enrich people's experience through detailing various dimensions of experience. We believe, through the introduction of a prescriptive tool which makes this reciprocal relation visible to designers, interactive products, which can afford – not enforce – various experiences, can be designed. The present study deals with this issue and tries to lay down the foundations for a prescriptive formulation of the design for long-term experience. In the following lines, we explain the methodology of the studies we followed to achieve this purpose.

3. Background on the PLUX model and backcasting approach

In order to propose a tool to assist the designers to design for long-term experience, we followed a straightforward, three-step process (Table 1). As previously discussed, understanding how the experience changes over time is vital to design for long-term experience (Han 2016; Karapanos et al. 2010). Therefore, we first explored the lifespan of people's experience of interactive products, and how their previous experiences affect the way they experience new products (Boğazpınar et al. 2014). Instead of utilising an existing model, we argued the importance of developing a new one that can capture the qualities of experience in detail and can easily be utilised by designers throughout the design process. The resultant model, Path of Long-Term User Experience (PLUX), reflects human-related and product-related qualities as well as the relations among them in detail, and will be presented further in section 3.1. We build upon the terminology introduced by Hassenzahl (2003) for categorising the qualities of the products that create experiences. In simple terms, the products have pragmatic (such as functions) and hedonic qualities (such as personality) which result in rich user experiences (for more detailed definitions see: Hassenzahl 2018).

The second step was about generating an approach around the PLUX model to facilitate a design process for long-term user experience. For this, we adapted backcasting approach that was originally developed to create inspiration for designers by starting from the desirable end-goal or future, and tracing backward to connect the desirable future to present (Ilstedt and Wangel 2014). In the adopted version of the backcasting approach, the designer starts with the question of 'what the next product could be' without considering the boundaries of the current technologies. This helps the designer to manage the mental blocks that might restrict them from thinking 'out of the box' (Karahanoğlu and Bakırlıoğlu 2017). To facilitate this, we developed the materials to be used during the design process (Karahanoğlu and Bakırlıoğlu 2017). The third and final step included two complementary studies on (1) testing the applicability of backcasting approach and the usability of workshop materials, and (2) evaluating the implementation of PLUX model to facilitate design for long-term experience (Table 1).

We presented the details of 'experience exploration' and 'method generation' steps in previous papers (Boğazpınar et al. 2014; Karahanoğlu and Bakırlıoğlu 2017); still, their results are summarised in the following sections 3.1 and 3.2, to provide the reader with the context of these studies. This paper unfolds the studies in the third, 'design with PLUX' step in detail.

3.1. Experience exploration: development of the PLUX framework

Upon analysing existing models of experience, we explored people's experience with interactive products with an aim of defining a prescriptive tool to guide designers to design for long-term experience (for details, see Boğazpınar et al. 2014). While every experience is unique, we tried to unravel the similarities in product qualities that result in somewhat similar experiences and human-related qualities. The scope of this exploration was limited to personal interactive products, revealing

Table 1. Outline of Our Methodology.

	Research Question	Methodology	Outcome
Step 1: **Experience Exploration**	How do users experience personal interactive products?	Interview with 20 users of personal interactive products	Path of Long-Term User Experience (PLUX) Model (Boğazpınar et al. 2014)
Step 2: **Method Generation**	What could be the approach for designing with PLUX?	The proposition of a backcasting approach to design with PLUX	Workshop materials (*see* Appendix and Karahanoğlu and Bakırlıoğlu 2017)
Step 3: **Design with PLUX**	How useful can PLUX model be in the design process of interactive products?	**Study 1:** Testing backcasting and workshop materials **Study 2:** Testing the usefulness of PLUX in the design process	An approach for 'designing with PLUX'

qualities related to this product group. We conducted a series of semi-structured interviews with 20 participants on their experience with personal interactive products, and as a result of their analysis, we proposed the Path of Long-Term User Experience model (Figure 1). Extending and merging the previously developed user experience models, and observing the common qualities that achieved long-term user experience, we suggest that the use of an interactive product has four phases:

(1) *Before acquiring:* Prior experience with interactive products affects user's expectations from the new product, as s/he feels a certain degree of commitment to previous product features and qualities. This mental commitment must be unfolded by the new product with new and richer experiences.
(2) *Learning:* User begins to explore the product and tries to understand its features and capabilities.
(3) *Mastery:* User either decides to integrate the product into his/her life or stops using it by filtering what has been learned in the previous phase.
(4) *Post-mastery:* User internalises the product and considers the product as an indispensable part of daily life. In the end, the *post-mastery* phase leads to the first phase of the next product, that is, before acquiring.

This model aims to help design practitioners understand the experience of interactive products and present them human-related and product-related qualities, and their relations to facilitate the design for long-term experience process.

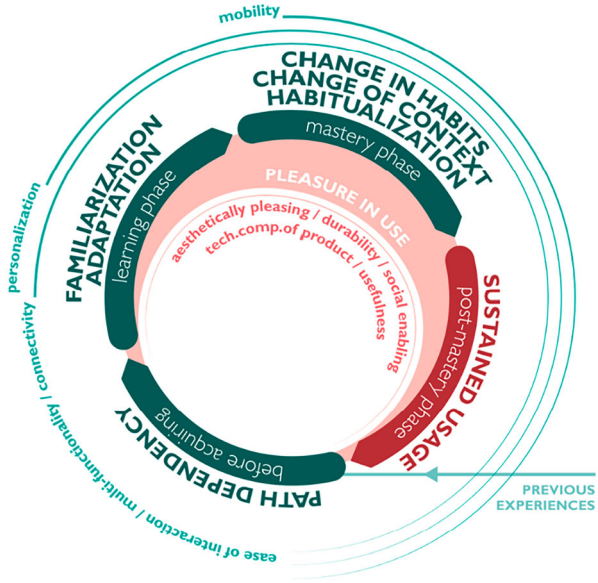

Figure 1. A simplified representation of the Path of Long-Term User Experience (PLUX) model.

Several layer-based models explore the experience of interactive products, such as the ones of Karapanos et al. (2009) and McCarthy and Wright (2004). However, these models do not take the previous experiences of users into account as the trigger of new experience. Our model is different than product-centred models as well (e.g. Desmet and Hekkert 2007), in the sense that we explain each phase of experience with human-related qualities as well as product-related ones. Our model draws similarities to the extended model of product experience states (see: Fokkinga et al. 2014), in the sense that both models propose an alteration in people's experience. That model expresses two levels of experience – product and overall – which could be compatible with what we called product and human-related qualities. Differently, our model emphasises the relations between the product qualities and the human-related qualities of experience. We believe that these qualities make our model unique, such that designers can further relate to these qualities with the stage of long-term user experience of interactive products.

3.2. Method generation: backcasting approach and design of workshop materials

We investigated how the PLUX model could be employed in the design of interactive products. Several practical methods and principles have been applied to user-centred design (van der Bijl-Brouwer and Dorst 2017). For instance, there are a few approaches that present toolkits to support designers in designing for experience. In one of the studies, focusing on the several aspects of experience, researchers propose a design methodology toolkit which consists of experience interviews, need definition, brainstorming and user testing (Pollmann et al. 2018). This toolkit combines existing tools and methods to assist the designers in human-centred concept generation. Another common approach used in design for experience is card-based idea generation tools, especially for creative thinking, problem-solving and human-centred design (Roy and Warren 2018). One example of this, although not utilised specifically for long-term user experience, focuses on designing for emotions (Yoon, Desmet, and Pohlmeyer 2016). However, the researchers report that using cards in the idea-generation process sometimes results in reduction in the translation of ideas into meaningful product properties. To note, there are not many approaches that integrate considerations for (long-term) user experience into the design and product development process (Varsaluoma and Sahar 2014). This is the gap in literature we positioned our study in, through the development of a long-term user

experience model and exploring how it can be utilised in the design process.

To achieve our goal, we defined a set of criteria to go through the phases of the model. We integrated the backcasting approach (Robinson 1982, 2003) into the design of products to explore if and how the PLUX model can inspire designers to contemplate on all phases of users' experience of interactive products, including before acquiring, learning and mastery phases. We weren't interested in designing the exact end experience, as that is contradictory to designing for experience. Rather, we anticipate and support the idea that both the product and the experience change during use. Accordingly, with the backcasting approach, the designers first design for long-term experience in the post-mastery phase and define the qualities of experience; then trace back and detail the experience according to initial use phases (i.e. before acquiring, learning and mastery) and the relations among human-related and product qualities of the PLUX model. To facilitate this process, we designed a set of tools that could be used in the design process, and for this paper, in design workshops.

Design tools can be used to facilitate workshops easily and timely, which can include time and experience charts, coloured papers and evaluation labels, depending on the aim of the workshop (Hanington and Martin 2012). By comparing different examples, we designed the workshop tools and conducted preliminary work to investigate whether the materials were understandable. After this preliminary work, any tool that may cause misunderstanding was corrected and the materials were designed into the final version. These included (i) descriptions of each stage of the model, (ii) descriptions of the product and human-related qualities in the model and (iii) empty A3 sized papers for the participants to detail and finalise their products. We presented examples of these tools in the Appendix and the way the workshop was structured more in detail in a previous conference proceeding (Karahanoğlu and Bakırlıoğlu 2017).

4. Methodology: design with the PLUX model

We conducted two design workshops, utilising the PLUX model during the design process with the backcasting approach. In the first one, we tested the usefulness of the workshop materials and the backcasting approach, and in the second one, we tested the usefulness of the PLUX model in the design process with the backcasting approach.

For the first workshop, we posted an online registration form to invite the participants to a month before. We invited 20 participants out of the 27 applications. All the participants were registered to 3rd or 4th-year industrial design bachelor programs in TOBB Economy and Technology University, Middle East Technical University and Gazi University, Ankara, Turkey. The criterion set while selecting the participants was the 'first comes, first served' rule. In the end, the workshop was conducted with 19 students as one of the students dropped out at the very last minute.

One week before the workshop, we sent a pre-workshop guide to all the participants. This guide consisted of the guidelines for (i) conducting a pre-interview with one randomly selected user of a personal technological product, with the interview questions, and (ii) filling in the graph (*see* Appendix, Interview Notes Template). The model was also introduced to the participants, in relation to the graph and interview questions. Following these, we emailed an invitation to a group of experts of design and user experience research, for the discussion of the utilisation of the workshop tools and backcasting approach in design with PLUX model. In the end, five experts responded positively to our invitation.

On the day of the workshop, after a 30-minute briefing about the workshop process, the participants were introduced to the details of the PLUX model (i.e. the relations between human-related and product-related qualities, their definitions, and their meaning in different use phases). After that, the participants were divided into groups of four, and each group decided on the interactive product they wanted to design in relation to the interviews they conducted. The workshop took about six hours in total with a final presentation and discussion of the workshop outcomes.

During the workshop, we asked the participants to start by designing a final product that they would like to come up with. We expected them to pursue the design process from the 'post-mastery' phase. With this conceptual product design solution in hand, we wanted them to continue the design process backward from the 'post-mastery' to 'mastery', 'learning' and 'before acquiring' phases in this order, responding to the human-related qualities of each phase through affecting product qualities. We allocated one hour for each phase during the workshop. At the end of the workshop, the participants presented their design outcomes and received feedback from the invited experts. The main role of the experts at this stage was to evaluate the outcomes of the workshop and the appropriateness of the backcasting approach.

Finally, the participants were invited to give feedback about the impact of the method on their design process through an online survey consisting of both open-ended questions and Likert-scale questions. Due to the limited

number of participants, we analysed the quantitative data emerging from Likert-scale questions separately and utilised them to assist the analysis of individual responses to open-ended questions, through regarding ratings '4' and '5' as positive, ratings '1' and '2' as negative, and the rating '3' as neutral. The clusters in Table 2 in the following section emerged from this grouping. The form had questions about (1) the backcasting approach; (2) the materials of the workshop, and (3) integration of the PLUX model.

In the second study, in accordance with the criticism of the experts and participant feedback we received in the first study (this is presented in the following section), we further explored the usefulness and applicability of the PLUX model in the design process. The backwards designing workshop with the PLUX model of the second study was conducted after new design concepts were developed for a provided design challenge. This allowed us to better evaluate the impact of the PLUX model on the design process, especially on detailing for long-term user experience. The model was utilised to explore how long-term user experience would be achieved starting from the *post-mastery* phase of the PLUX model to *before acquiring* phase. Having developed design concepts at hand with contemplated usage scenarios, the participants reflected on the users' process of completely adopting these design solutions through backcasting to the initial phases (i.e. before acquiring, learning and mastery).

For the second study, we developed the design challenge around a future use case scenario of an interactive product that would facilitate 'cryptocurrencies as daily transaction medium'. In addition, we integrated the PLUX model and backcasting approach at the end of a 3rd year Bachelor's course in Industrial Design Engineering Programme of University of Twente, the Netherlands. In the course, 76 students spent 7 weeks to individually conduct needs and experience analysis. During this period, they were introduced several models of experience and they submitted two assignments: (1) exploring the needs of users (week 2) and (2) exploring which of these needs can be responded through design for experience (week 5). The PLUX model was briefly introduced to the students one week before they submitted the second assignment, but the model was not structurally included in the assignment definition. Students had the chance to get feedback from the course coordinator as well as their fellows on their ideas and concepts.

Afterward, a design workshop was conducted in week 7, in which we explained the PLUX model in detail, and asked students to further develop and finalise their concepts in line with the PLUX model. Since the students already had design ideas that they developed through previous assignments, this workshop was structured differently than the first study. Already having ideas and concepts built around target user groups, needs analysis and use scenarios, the students were expected to iterate their concepts through an understanding of long-term user experience with the PLUX model and experience phases of 'before acquiring', 'learning' and 'mastery'. As a result of the workshop, the students submitted the developed concepts, an example of which is shown in Figure 3 (*in Section 5.2*).

5. Results of the studies

5.1. Study 1: testing the workshop materials and the backcasting approach

The outcomes of the workshop were collected to provide an understanding of the possibility of 'designing with the PLUX model'. Starting from the experience of different products and focusing on all aspects of our model, each group developed very detailed product ideas within a short period of time. It was observed that apart from focusing on the qualities we provided in the experience model, the participants extended their ideas by considering the contextual factors (i.e. outdoors or indoors) and user groups (i.e. children, adventurers or cooks etc.). This enhanced the outcomes of the workshop with detailed explorations and iterations.

In this workshop, five groups developed five different consumer products (i.e. sports watch, smart cam, smart screen, children's smartwatch and smart earphones). Although the design solutions themselves were interesting on their own, the aim of this paper is to understand how the participants and experts perceived the integration of the PLUX model through a backcasting approach into the design process and how this integration affected the outcomes. Therefore, in the following lines, we will discuss the usefulness of workshop tools as well as the backcasting approach and PLUX model.

5.1.1. Usefulness of the workshop tools

The tools in the workshop (*see* Appendix) were meant to ease the understanding of the PLUX model and facilitate the design process efficiently through structuring the workshop stages. In the online survey, the participants were also asked to assess these tools in terms of clarity and inspirational quality. In terms of clarity, all the information provided textually (i.e. definitions of qualities) and visually (i.e. a representation of the PLUX model in Figure 2, and different sketching papers prepared for each use-phase) were found clear and easy-to-

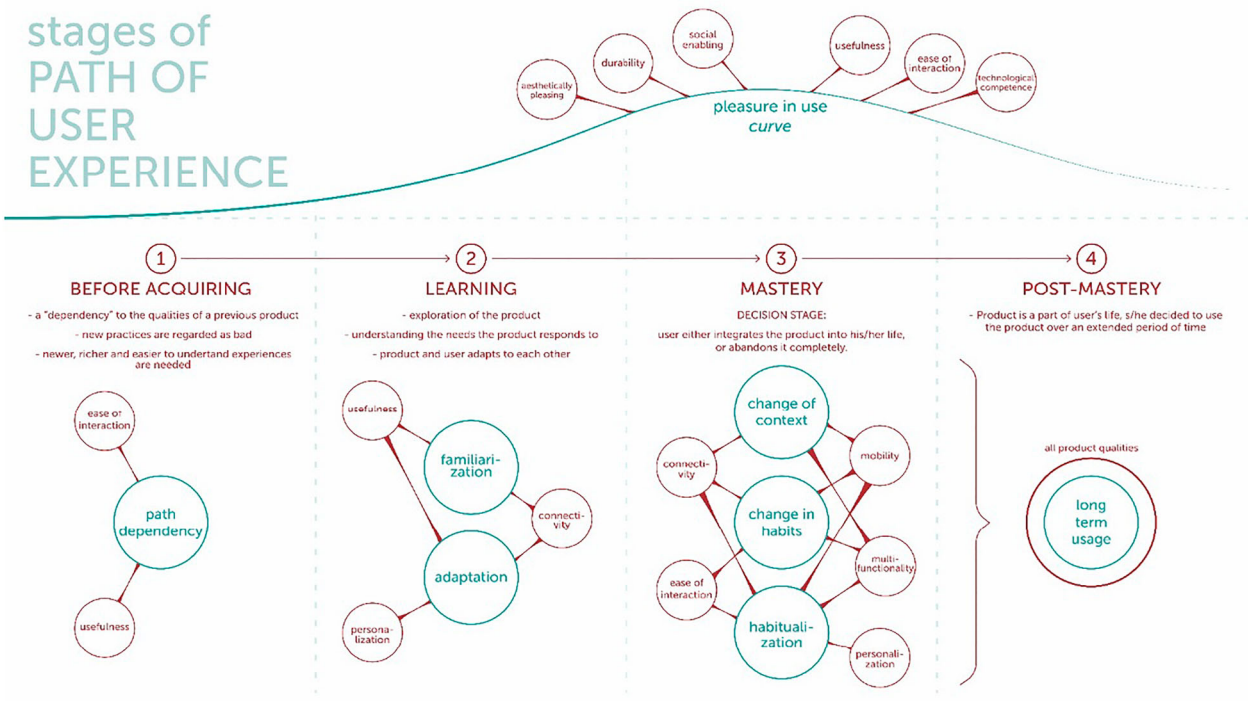

Figure 2. A more detailed representation of the PLUX model, showing the relationships between product qualities and human-related qualities in each long-term user experience phase. (Green circles stand for human-related qualities while red ones are for product related qualities).

understand. Through the simplification and the visualisation of the model, the participants were able to comprehend and utilise the model throughout the workshop. The wording of the terms and their explanations were found easy-to-understand as well. About the inspirational quality of the tools, the participants responded from various perspectives. Three of the participants found the tools more informative than inspiring and mentioned that these tools cannot inspire, but they can ease the design process by providing aspects to focus on during the idea-generation. Two of the participants suggested the use of product examples that display the relations between human-related and product qualities in order to make the tools more inspiring. We doubted that the use of product examples could be leading in a way that clouds the design process; hence, the visual examples were completely excluded from the tools. This decision could be questioned in further studies to figure out a way to include examples that inspire, yet do not cloud the design process.

5.1.2. Usefulness of the backcasting approach and PLUX model

Upon the online survey we conducted with all 19 participants of the study, three main groups emerged according to the purpose and usefulness of the backcasting approach and PLUX model. These groups cover participants: (1) that found both the approach and the model useful, (2) found the model useful, but not the approach, and (3) found neither the model nor the approach useful. A summary of these groups' thoughts and comments are summarised in Table 2.

Table 2. Participants feedback on the integration of PLUX model and backcasting approach.

	Group 1–10 participants	**Group 2**–7 participants	**Group 3**–2 participants
Path of Long-Term User Experience Model	(+) user-needs focused approach (+) design considerations (+) human-related qualities in use stages (+) relationship between product and human-related qualities	(+) design considerations (+) relationship between product and human-related qualities (+) helps with mental blocks	(?) more appropriate for testing design ideas (?) more appropriate for creating marketing strategies (-) hard-to-understand model
Backcasting approach	(+) backward designing (+) step-by-step process focusing on each use stage	(-) unusual process (-) deciding on a final design idea too early (-) not specified target user group	(-) unusual process (-) deciding on a final design idea too early

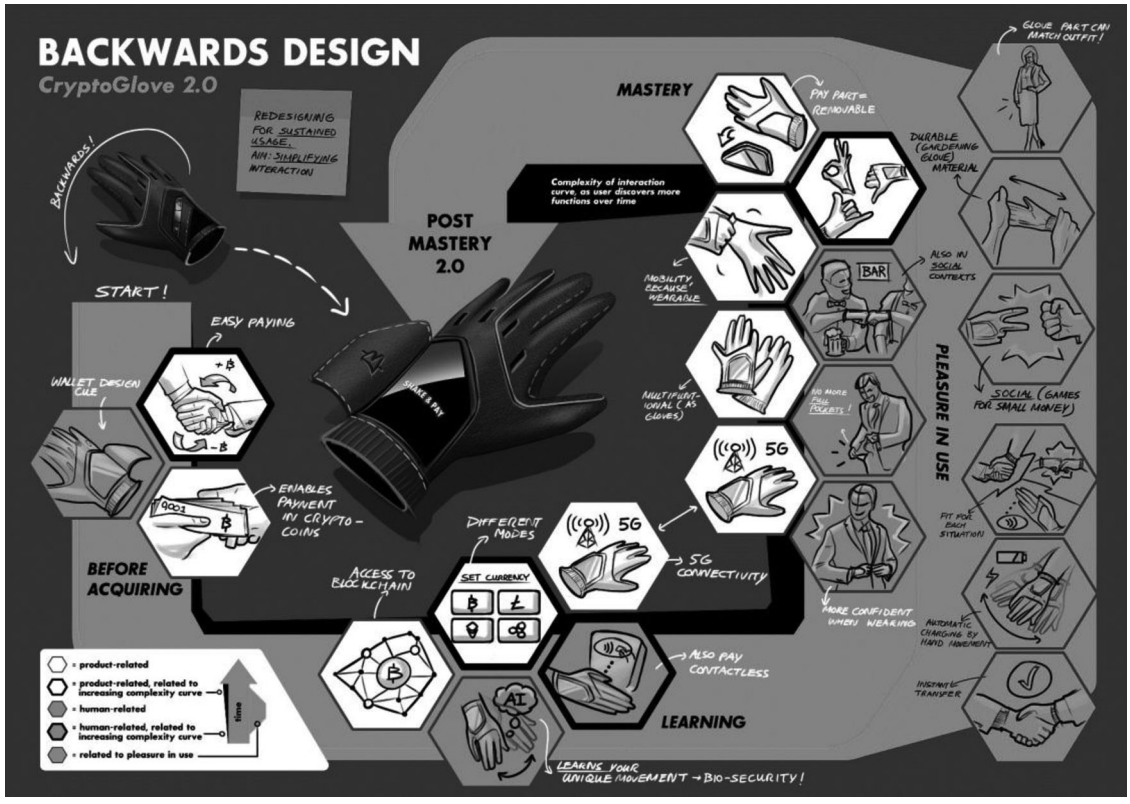

Figure 3. An example of PLUX workshop outcomes, CryptoGlove 2.0 by Vitto Bonnemayers illustrating the use phases and how product qualities affect human-related qualities.

The first group consists of 10 participants who believe that the workshop was interesting due to its backward design approach. Such an approach was found inspiring and enabled the participants to easily generate ideas without getting blocked. Through the backward design approach, the process revealed important aspects to consider while designing technological products that engage their users and encouraged participants to respond to these aspects. This is also highly related to the PLUX model, which presents these aspects to designers, as the model is thought to provide such feedback. The use phases (i.e. before acquiring, learning, mastery, and post-mastery), the human-related qualities users pass through and how these are affected by product qualities are explained within the model, which in turn eased the idea-generation process:

> "[Designing according to the use phases] was absolutely useful. Seeing a map of important aspects to consider let the design process flow. If I am not following a certain model while designing, I try to configure a makeshift model and explore different approaches simultaneously. On some occasions, it is a good thing, but mostly, it is tiring and inefficient." *Participant 10*

A recurring point expressed by the first group participants was the model's user-centred approach, through the human-related qualities. They found the model and the backcasting approach especially useful for creating user-centred design solutions. Although the model revealed how product qualities affect users and their adoption of a new technological product, it was the step-by-step, backward structure of the approach that enabled more in-detail and comprehensive reflection of every phase users go through.

The second group consists of seven participants who believe the PLUX model is useful. However, this group of participants had reservations about using the approach in the future due to backcasting structure and real-life expectations from designers (i.e. very structured project briefs followed by already established design processes).

Regarding the PLUX model, the participants generally believe it helps with developing user-centred solutions as the model presents a very detailed account of relations between product qualities and human-related qualities. Designing according to the use-phases (i.e. before acquiring, learning, mastery, and post-mastery) through following an experience model enabled these participants to efficiently develop solutions for specific human-related qualities. It enabled swift conceptualisation of what needs to be considered in each use stage during the design process and were found especially useful against mental blocks. However, the

participants were not satisfied with the approach due to one shared reason: Confusion. The participants designed the last use-stage (i.e. post-mastery) first; thus, they were unable to develop it further to respond to the human-related qualities of the prior stages. Through designing the last stage, they believed they finalised the design solution too early, and they generally did not understand why they had to develop a finalised idea further.

Some of the participants within this group indicated that, in the beginning, they were not clear about how to merge the results of the interviews with the design process. For this, we thought that the target user group of each team in the workshop would be selected according to the people the participants have conducted interviews with before the workshop. This aspect of the target group selection was also embedded when the participants discussed the outcomes of their interviews before starting the idea-generation process. As a reflection, the researchers should have made it clearer that the participants were to develop design solutions for target groups that encompassed their interviewees.

The third group consists of two participants. These two participants both believed that utilising the PLUX model was hard as they were not accustomed to working on such a model. One of them stated:

> "It is not like I found the model insufficient or inefficient, but it is a model that I simply cannot work with because it is hard to use. Maybe I can use it for assessing my ideas when the design process is nearly finalised." *Participant 12*

The whole workshop was developed to utilise the PLUX model with the backcasting approach. Hence, it is assumed that the comments are more steered towards the application of the model within the process. In fact, both of the participants stated that the model could be restrictive for idea-generation, as it presents many aspects to consider while designing such devices. When combined with the backcasting approach, these participants felt limited with their initially created ideas and could not develop those ideas further.

At the end of the workshop, after the participants presented their ideas, the whole process was evaluated by the invited experts. Accordingly, the backcasting approach was appreciated by the experts in general. Designing the post-mastery stage (i.e. the final stage of experience in our model) seemed logical to prime the participants to create something new and different, and to enable them to think beyond the current experiences and context. How starting with different phases in different orders could affect the outcomes was pointed out as another interesting topic of investigation in further studies.

Even though we believe that designing should be stage-based and iterative, one of the limitations of Study-1 was that it was a one-stage and non-iterative study. This was also highlighted by the experts invited to assess the usefulness of the model in the design process, as they expressed concerns over generating a design idea so quickly within first hour of a workshop. Still, we believe that the goals of the study were achieved. On the other hand, the utilisation of another idea-generation tool or providing the participants with future scenarios was suggested for designing the post-mastery stage (and the next product). Due to the reliance on previous user experiences derived from the interviews conducted prior to the workshop, the participants could not detach the idea-generation from existing uses and experiences. Although PLUX is a useful model to design for all the stages of long-term user experience and to facilitate the adoption of the next product with new types of experiences, as mentioned in the previous section, it fails to facilitate totally new and creative focuses on different stages of experience of the next product. Therefore, we set up the next study as a stage-based and iterative design for long-term user experience process with a future use case scenario and incorporated the PLUX model to iterate design solutions.

5.2. Study – 2: design for long-term experience with PLUX model

For the second study, 73 of the students who attended the workshop submitted developed design works. To understand the usefulness of the PLUX model in the design process, we conducted a systematic analysis of the design outcomes. By using content analysis, we compared the concepts that the participants developed before the workshop, with the ones they submitted after the workshop. In this analysis, we sought for the product and human-related qualities that participants touched on in their previous concepts and the qualities that they focused on during the PLUX workshop differently. At the end of this analysis, 5 of the submissions were excluded as they did not show any improvements in relation to the PLUX model.

At the end of the workshop, we invited the students to submit a short reflection report, in which they were asked to give feedback on the pros and cons of working with the PLUX model. In total, 74 out of 76 participants submitted a reflection report. Of the submitted reports, 16 were excluded as they only reflected on the design solutions and provided no insights into the PLUX model or the workshop. Hence, the analysis includes 58 reports that specifically reflected on the positive and negative aspects of working with the PLUX

model. We conducted a thematic analysis of each reflection report in which we sought for the clusters in the data (Vaismoradi, Turunen, and Bondas 2013). Our goal in doing this was to come up with narratives and latent contents without missing the context of data.

The backcasting approach we adopted during the design workshop was the same as the first workshop. Therefore, rather than repeating the workshop structure we followed in the first study, we will explain the analysis of workshop outcomes and the reflection reports, and discuss the usefulness of PLUX model in the design process.

5.2.1. Analysis of the PLUX workshop outcomes

The results showed (Figures 4 and 5) that participants focused on various qualities of the PLUX while developing their concepts. Not surprisingly, different product and human-related qualities were more prominent in idea generation and final concept development phases.

Accordingly, while aesthetically pleasing ($n = 61$) and ease of interaction ($n = 49$) are the most paid attention qualities in the idea generation, personalisation ($n = 51$), connectivity ($n = 43$), multifunctionality ($n = 34$), mobility ($n = 32$) and usefulness ($n = 30$) were the ones that the participants brought forward in their final concepts. Ease of interaction was also paid attention by a noticeable number of participants in the final concept ($n = 30$).

Notably, the participants incorporated the human-related qualities in the final concepts (Figure 5). In particular, path dependency ($n = 31$) and familiarisation ($n = 21$) were the most referred human-related qualities. Other human-related qualities (i.e. adaptation, change in habits, change of context and habitualisation) were all considered more in the final concepts, while sustained usage was incorporated slightly less ($n = 7$) compared to the idea generation phase. These results confirm that during the workshop, taking their early design decisions into account, participants extended their ideas by considering the dimensions of PLUX model.

The results also showed that, while developing their concepts, the participants elaborated on the relations between the product and human-related qualities, and built different relations among the product-related qualities than we expected. Hence, in the following lines, we will highlight the usefulness of the model in relation to those interpretations.

5.2.2. Interpretation of relations between product and human related qualities

During the analysis, it became evident that the participants elaborated more on the definitions of product and human-related qualities we provided them and drew different links between them. One of the most interesting findings was that participants focused on the path dependency quality in their works more than any other human-related quality (Figure 5). It was clear in their works that they employed several product-related qualities to break the path-dependency of their target users.

As was indicated before (also see Figure 4) most of the participants integrated personalisation, connectivity, multifunctionality and mobility in their final concepts. Surprisingly, a group of participants employed these qualities in a way that they can break the path dependency of users and establish new experiences. For instance, some of the participants designed wearables for payment, and envisioned personalised ways of interaction to carry out exchange tasks, as exemplified through various gestures that can be saved and used by users for specific tasks including product-product interactions initiated through these gestures. This was an interesting finding, because, in our early findings, we reported that ease of interaction and usefulness help the users to find a way to interact with new products in a more comfortable way (Boğazpınar et al. 2014). On the other hand, qualities such as multifunctionality, connectivity and mobility come into prominence in mastery phase of long-term user experience. However, the participants of the current study went beyond the utilisation of ease of interaction and usefulness as path-dependency breakers and suggested that the qualities of mastery level could also be dwelled on to break the mental barriers of users. These qualities were further developed to facilitate familiarisation and habitualisation of users with the new technology.

Not surprisingly, concentrating on the use context of the experience was a common tendency of the participants. Some of the participants suggested that the use context could also be employed to break the mental dependency of users. With this focus, it was clear in the final concepts that two most referred human-related qualities were expanded further (path dependency and familiarisation) to catalyse habitualisation faster. As an example, one of the participants suggested that solutions to make cashier payments with cryptocurrencies can first be implemented in existing contactless payment devices, through incorporating a similar contactless payment surface on the other side of the payment kiosk. This way, users could be offered two different ways of payment, until they get accustomed to the idea of paying with cryptocurrencies. Even a number of the participants explicitly indicated that experiencing these types of features, their concepts can assure (technology) adoption, and thus products become an integral part of the users' life. These suggest that through the incorporation of PLUX model into design detailing, the participants considered beyond

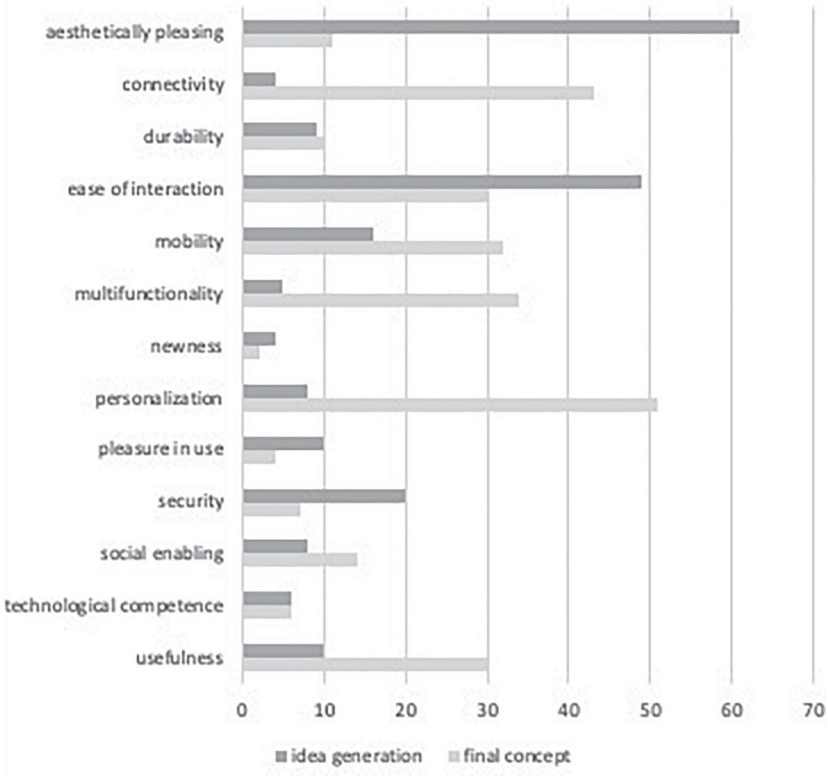

Figure 4. Number of participants referring to product-related qualities of PLUX model in their design work.

the product itself and suggested design solutions for their use context as well.

5.2.3. Interpretation of relationships among product qualities

The outcomes of the PLUX workshop revealed that some of the product qualities were mainly utilised to focus on the possible expectations of the users, especially by merging product qualities to create unique experiences. Personalisation of interaction exemplified in the previous section falls under this. In addition, security through connectivity and mobility was observed in many outcomes. Some of the participants put forth wearable design solutions for unlocking other interactive products (e.g. computers, digital locks, etc.) when the wearable crypto-wallet is within a certain proximity. Another interesting relationship was observed between the qualities of durability and aesthetically pleasing. These qualities both affect the pleasure in use (human-related quality), however for this project, the participants adopted durability not only in terms of physical endurance but also as an aesthetic feature. Finally, the most interesting merging was social enabling and usefulness. It was observed that many participants explored the opportunities for monetary exchange activities and enhancing them as more social and intimate.

While the above-mentioned merging of product qualities in practice shed light on how the PLUX model can be interpreted by designers in a positive light, and facilitate creativity, some of the product qualities were also framed rather plainly by some participants. For example, mobility was interpreted as the disappearance of the currency exchange problem around the world for travelling. Not only this interpretation is different than how we presented it to the participants, but also it shows that mobility can be interpreted as *travel* rather than the everyday activity it suggests. This was a result of using the PLUX model as a checklist, which will be presented in the next section.

5.2.4. Results of reflection reports

To grasp the general tendency of the feedback about working with the PLUX model, we first read all the reports and categorised the comments into two: general comments and comments on the impact of PLUX in design. 26 of the participants specifically mentioned that the model is very detailed and comprehensive. In addition, it was found to be useful ($n = 19$ participants), helpful ($n = 6$ participants) and practical ($n = 6$ participants). It was indicated that during the idea generation phase, designers need guidance to thoroughly understand the qualities of experience. Articulating the phases of experience, the PLUX model was found useful and helpful in providing a different perspective on the design process by reconstructing the experience with

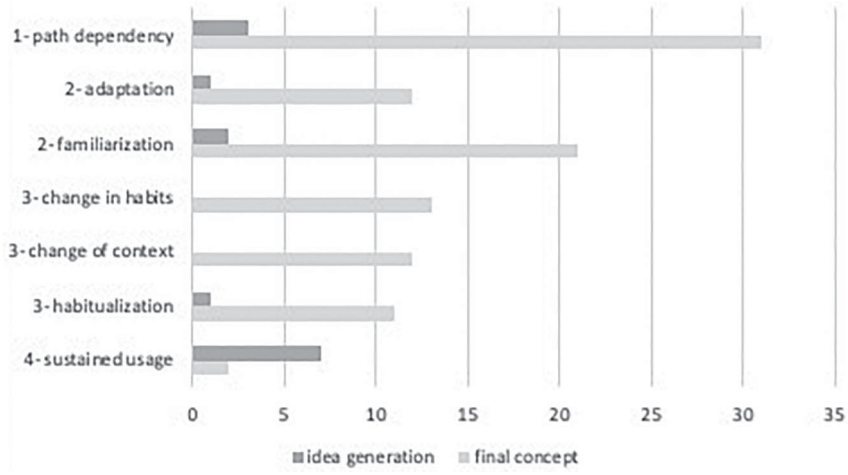

Figure 5. Number of participants referring to human-related qualities of PLUX model in their design work.

the qualities of experience. The practicality of the model stems from its effort to put forward the connections between those qualities and the phases of experience. Those connections make the model easy to understand and usable during the design process.

On the other hand, some of the participants indicated that the model would work better with other models of experience they had been introduced to before ($n = 7$ participants). It was mainly because the model was indicated to miss the connection between the phases of experience and emotional outcomes of the experience. Even though there is an emphasis on pragmatic and hedonic qualities of products at different phases of experience, the PLUX model doesn't specifically focus on emotional outcomes of the experience. The aim of the PLUX model is not accounting for every variable affecting the overall experience, but presenting the qualities that can facilitate new technology adoption and long-term usage. Following our previous discussion on design for long-term experience, the purpose here is not designing and ensuring a certain kind of experience, it is about designing products that can afford various kinds of experiences.

In parallel to the general positive tendency, the positive impact of PLUX was significant ($n = 91$ comments) compared to the negative impact of it ($n = 18$ comments). To elucidate the impact of working with PLUX model, we further grouped the comments into two: (1) broadening designers' perspective and (2) grounding design decisions (Table 3). We will discuss these impacts in the upcoming sections in detail.

5.2.5. Broadening designers' perspective

It was evident from the comments that the PLUX model helps the designers to further empathise with the users ($n = 28$). Essentially, that was one of the reasons why participants indicated that the model is useful. It was emphasised that through the model, it was easy to understand how a product can satisfy user needs at each phase of experience. Thus, failing to satisfy the needs of users, the product might end up with abandonment and not being part of their daily lives. Therefore, evoking the critical and systematic thinking skills of designers ($n = 10$), the PLUX model was regarded as a powerful way of extending use cases ($n = 4$) and addressing the emotions of the users ($n = 1$). At some point, participants were able to think of different use cases than the ones they previously thought of, including use cases for early stages of use. This particular aspect of the PLUX model

Table 3. Summary of participants comments in Study 2 on designing with the PLUX model and backcasting approach.

General Comments	Broadening Perspective	Grounding Decisions
(+) detailed & comprehensive, [26]	(+) empathising with users [28]	(+) works like a checklist [12]
(+) useful [19]	(+) focuses on different stages of PLUX model [22]	(+) good for detailing [7]
(+) helpful [6]	(+) enables systematic / critical thinking [10]	(+) focuses on different aspects of products [2]
(+) practical [6]	(+) extends use cases [4]	(+) concretises the qualities [1]
	(+) enables working with emotions [1]	(+) focuses on functions [1]
	(+) new insights about user experience [1]	(+) ways to explain meanings [1]
(-) works better with other models [7]	(-) restricts creativity [4]	(-) results in over-design [2]
(-) confusing [1]	(-) does not focus on emotions [3]	(-) too function-focused [2]
(-) doesn't result in major changes [1]	(-) does not focus on meaning [3]	
	(-) over-generalised [2]	
	(-) does not focus on personality [1]	
	(-) only focuses on positive experience [1]	

facilitated making the connection between the qualities of the new product and the previous products.

> "I found it useful to go through all phases of experience and see whether I had accounted for all of them. It gave me a broader view of how a user would use a product. It forces you to look at use phases a designer might not have thought of at the beginning." *Participant 42*

In parallel to the previous comments, participants indicated that one of the most powerful characteristics of the model was the fact that it focuses on different stages of experience ($n = 22$ participants) that further entitles the designer to 'expand the phases of experience', and somehow embrace new insights about user experience ($n = 1$ participant).

> "With the PLUX Model, you are encouraged to look at your own design like somebody who hasn't seen it before. In this manner, it becomes clear if your product has a good projection of interaction with users." *Participant 30*

Besides the positive impacts, a number of restricting impacts of the PLUX model were mentioned. Being very detailed, it was indicated to restrict creativity ($n = 4$ participants) by not focusing on emotions ($n = 3$ participants) or only focusing on functions ($n = 3$ participants). In relation, one of the criticisms was the overgeneralisation of user experience concepts ($n = 2$ participants). Both not focusing on product personality ($n = 1$ participant) and only focusing on positive experience ($n = 1$ participant) were indicated to block further broadening designers' perspectives. There are certain points that this criticism puts valuable insights into the usage of PLUX model in the design process. These participants reflected that having such a 'checklist' restricts the creativity as they felt the urge to only think about the product qualities listed in the model. That was the main reason why they indicated that the model only focuses on functions, and thus the emotional aspects of experience and the reflections on product personality are missing. However, in a broader sense, the model emphasises the connection between human-related qualities and product qualities. While this emphasis is explicit in the model, the connection between the pragmatic (functions) and hedonic (emotions/personality) qualities of experience is not as such. Therefore, making this emphasis more apparent in the future studies could clarify the goal of the PLUX model in the design process.

5.2.6. Grounding decisions

The number of participants mentioned the impact of PLUX model on grounding decisions was lower than those who valued its impact on broadening designers' perspectives ($n = 36$ comments). However, it was found practical in the sense that it helps to ground the design decisions by contemplating how the product and its qualities would affect the use at different stages of experience.

By focusing on different aspects of products ($n = 2$ participants), such as functions ($n = 1$ participant) and meanings ($n = 1$ participant), the model was indicated to work like a checklist ($n = 12$ participants) and works very well for further detailing ($n = 7$ participants), which also helps to concretise designers' decisions ($n = 1$ participant). It was indicated to facilitate guidelines for reflecting on the way products are being utilised, and so stimulates further development and improvement of their appearances and the pragmatic qualities by using the model as a checklist of functions.

> "The Path of Long-Term User Experience model gives a supportive visual representation of the influences on the lifecycle of relations between products and their users. It facilitates guidelines for reflecting on the way products are conceived, hence encourages further development and improvement of its appearances and both passive and active functions." *Participant 14*

However, similar to the negative comments for broadening perspectives, working with the model was criticised to be too function-focused ($n = 2$ participants). Also, two participants mentioned that this model can easily ground decisions that would end up in overdesign ($n = 2$ participants). We realised this comment was highly related to the number of product qualities in the model, and the tendency to regard each product quality as different features present in the new product. However, product qualities need to be critically reflected on by the designer, since their relation to human-related qualities and the features required to respond to those qualities change according to different products and use scenarios. While the number of comments on this was quite low (2 out of 58 participants), this is an important point to consider while updating the workshop materials.

6. Discussions

In this paper, we reported the outcomes of two workshops that we conducted, in order to explore the possibility of utilising the PLUX model throughout the design process of interactive products. In light of our findings, in the following lines, we will discuss the research outcomes and their implications on the future of PLUX model in separate sections.

6.1. Discussion on the research outcomes

Through the analysis of the participants' reflections in both studies, two distinct strengths of the PLUX

model in the design process were revealed. Firstly, the participants of both workshops found that the four stages of user experience help designers to consider beyond the final use scenarios of interactive products, by broadening their perspectives on how these products are adopted and experienced by the users. Clarity and applicability of the model were important aspects of the studies, as we were concerned about the adaptability of the model by designers. The model facilitated the generation of rather detailed ideas related to overall user experience, as the participants pondered upon every affecting and affected quality presented by the model and transferred them into product features, scenarios, and interactions. It was emphasised especially that the step-by-step backward designing approach enabled them to individually focus on these phases more in detail. The second strength they mentioned was the well-clarified relations among product and human-related qualities. The PLUX model allowed them to empathise with potential users of the products and to re-evaluate their designs accordingly. Both these strengths drove them to further develop their designs through a 'design for long-term experience' lens.

Our research showed that the participants of the first study faced challenges to navigate through the model to come up with new design ideas. An expert who participated in the evaluation of the first study pointed out the hardness of coming up with an innovative design idea using such a detailed experience model and suggested to initially provide designers with a design challenge for a desired future product and to introduce the PLUX model at a later stage in the design process. This allowed the exploration of product and human-related qualities for a truly new design concept that was properly developed yet required insights in facilitating user adoption.

On another note, the participants created novel links among product and human-related qualities and explored their potential impact on long-term user experience. This was a welcome deviation from the model and demonstrates the inspirational quality of such a prescriptive model. Through acquiring an understanding of various product and human-related qualities affecting the long-term user experience, the participants evaluated these qualities in relation to their designs and reflected these interpretations by drawing new links among these qualities.

However, there were concerns raised about the level of detail in PLUX and how such a detailed model of experience can limit the creativity of designers. Although the PLUX model was introduced to the participants as a tool to better comprehend how user experience changes throughout a product's lifespan, it was regarded by some participants as a 'checklist' of must-have product features. The PLUX model is not an assessment tool or a checklist, but it is a design tool to aid designers with limited knowledge on design for long-term user experience and to implement this perspective into their design processes. On the other hand, we found in the second study that, some participants did not make any changes in their designs while working with the model. We further investigated if these designs were all well-developed. In the end, we found that, in some of those designs, there were still some points for improvement. Thus, we came to the conclusion that this could be a result of regarding the model as a checklist, and the model is not as useful when it is regarded as such.

The analysis of the design outcomes of the second workshop showed that designers merged some of the product qualities (e.g. multi-functionality, connectivity and usefulness qualities in the form of a proximity-unlock function), which revealed more opportunities for the design project at hand. This was an interesting finding, as results showed that the participants approached the PLUX model differently than we envisioned. In addition, some of the participants reinterpreted some of the product qualities (i.e. mobility) and some came up with new product qualities (i.e. security). We believe that these are promising findings as they show that the model can evolve and be updated when different types of products are the subject of the design process. We will discuss this possibility in the next section.

Even though we have quite some evidence in the effectiveness of the PLUX model in the design process, we did not investigate its utilisation in an iterative design process. Therefore, we do not have evidence about the effects of the model in the user testing stage yet. Considering the findings of our studies, we suggest the future designers regard our model and approach as a way to reflect on the stages of long-term user experience and, just as the participants of the second study did, exploit the potential to combine several product qualities, where possible. These results urge us to discuss the implications of the research outcomes of the future of the PLUX model.

6.2. Implications of research outcomes on future of PLUX model

At the beginning of our journey in investigating the interrelation between the product and human-related qualities in long-term user experience, we examined different user experience models (Boğazpınar et al. 2014), and started investigating how the PLUX model can be used in the design process (Karahanoğlu and Bakırlıoğlu 2017). The PLUX model was developed based on our research interest in explaining the dynamism of user experience

of personal, daily-use interactive products. After conducting two design workshop in experimenting with the backcasting approach, we come to two major conclusions about the future trajectories of PLUX model: (1) the model could be adjusted during the design process in relation to designers' needs, (2) it could be revised before the design process in which the outcomes of initial user research can be implemented better.

Firstly, our results showed that the PLUX model helps designers in the early stages of the design process. Unexpectedly, we found that some dimensions we defined in the model were combined and suggested as new qualities within the dynamism of the design process. 'Personalisation of interaction' exemplified in the previous section falls under this. As was indicated before (also see Figure 4) most of the participants integrated personalisation, connectivity, multifunctionality and mobility in their final concepts. Surprisingly, a group of designers employed these qualities in a way to break the path dependency of users and establish new experiences. We see this as an opportunity for designers to come up with additional product or human-related dimensions in relation to the demands of the experience design process. For instance, in the future, there can be other combinations of product-related dimensions such as 'personalisation of mobility' while a combination of product and human-related qualities can emerge as well. We believe this flexibility could also lead to fruitful and innovative design ideas.

Another future trajectory that we envision is the revision of the model. As we reported in the findings that, 'security through connectivity and mobility' was observed in many outcomes which do not explicitly appear in the PLUX model. On the other hand, we have found that not all the product and human-related qualities were referred to in the final designs (see Figure 4 and 5). It was because, depending on the type of experience being designed, some of the qualities were more important for the experience (such as ease of interaction) than the others (such as durability). These suggest that through the incorporation of PLUX model into design detailing, the designers considered beyond the product itself and suggested design solutions for their use context as well. We also see the possibility that the model could evolve when it is tested out in solving challenging design suggestions, such as designing personal health technologies for people with chronic diseases. When we reflect on these findings, we see the opportunity that the model could be revised before, and even during the design process, based on the user research findings, so as to match the requirements of the experience being designed.

There are several layer-based models that explore the experience of interactive products, such as the ones of Karapanos et al. (2009), McCarthy and Wright (2004), Desmet & Hekkert (Desmet and Hekkert 2007) or Mahut et al. (2018). We emphasised that our model is different than those models in explaining the relations between the product qualities and the human-related qualities of experience in long term experience. With our additional findings, we believe that its flexibility in the design process added up to the uniqueness of PLUX model in designing for long-term user experience of interactive products.

6.3. Limitations

One of the limitations of Study-1 expressed by the experts was that it was a one-stage study rather than an iterative one. We still see this as a limitation of the model and advise the designers that the usage of the model for ideation may limit the creativity of the designers. Even though we believe that the goals of the study were achieved, we think that employing the model in the design process, preferably coupling with co-design sessions in which the potential users can contribute to the concept development process, can result in more useful and applicable product iterations.

Another limitation of our study was that the evaluation of the model and the approach were done by the novice designers. For further studies, we suggest that the workshop tools could be adopted in the way we applied and our method should be further interrogated with real-world design challenges by more experienced designers. Also, we see potential in further questioning the relationship among multiple human-related qualities and revealing how the human-related qualities in initial use phases can affect the human-related qualities in the latter stages.

7. Conclusions

In this paper, we presented two different applications of the Path of Long-Term User Experience (PLUX) model in the design process and the opportunities and limitations of adopting it in terms of design for long-term experience. The first study aimed to explore the use of several design tools we developed, as well as the backcasting approach in the design process, revealing several strengths and limitations of these tools. Mainly, the PLUX model was found useful for design detailing rather than idea-generation, especially due to its detailed depiction of user experience in four phases.

The results of our studies show that designing with the Path of Long-Term User Experience model empowered the designers with detailed guidance about the stages of long-term user experience of technological

products. Throughout these applications of the PLUX model at different stages of the design process, we observed how a detailed user experience model impacts the design process and how designers utilise such a model to further improve their design solutions. The PLUX model will require further development and updating as the technology advances and changes along with users' interactions and expectations. However, the way it presents the product and human-related qualities under certain user experience stages provide valuable insights in terms of design for long-term experience, technology adoption and pleasure in use, especially when it is utilised with a supporting design methodology, like the backcasting approach adopted in the applications presented in this paper.

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Appendix

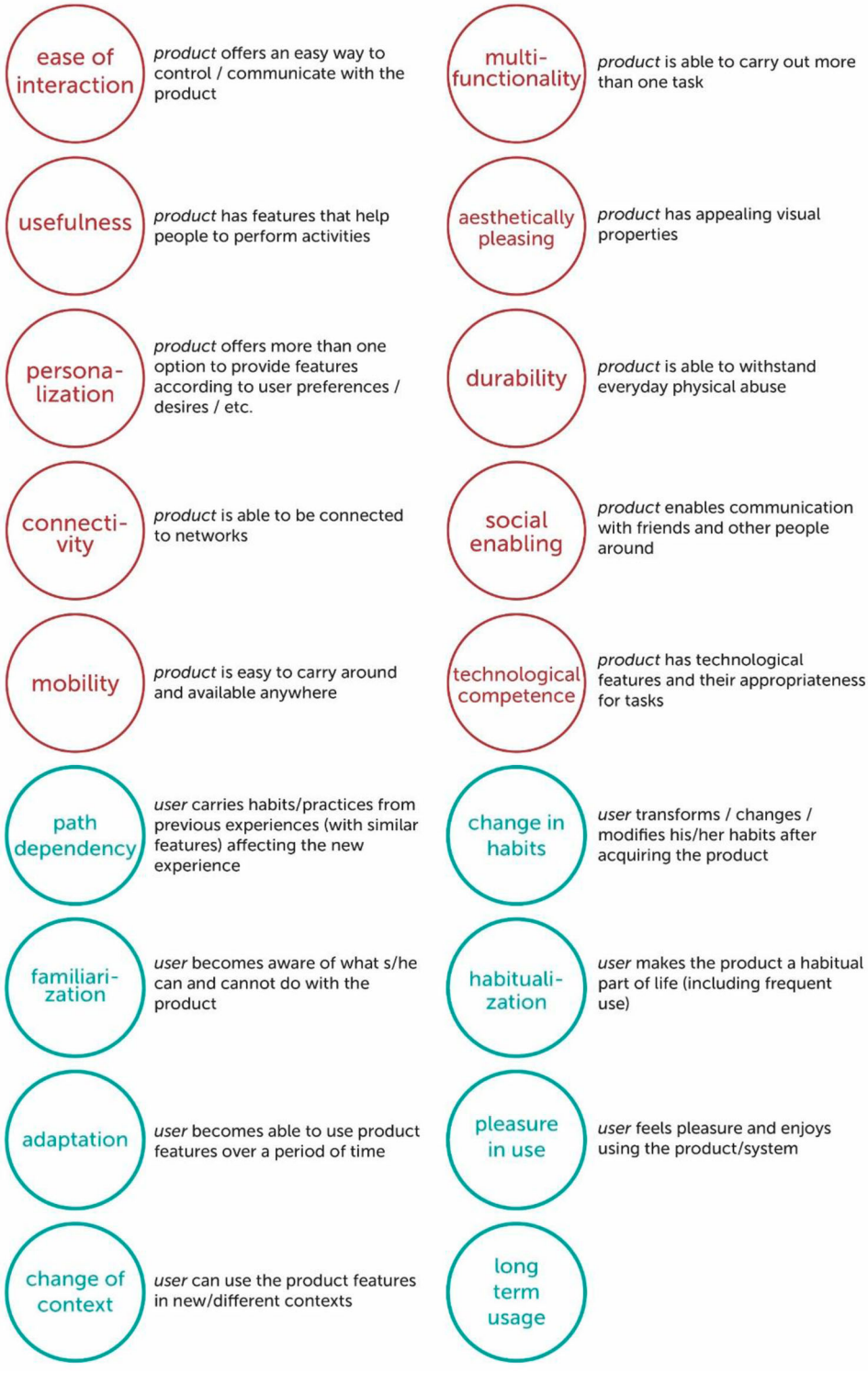

Figure 6. Product and human-related qualities and their brief definitions.

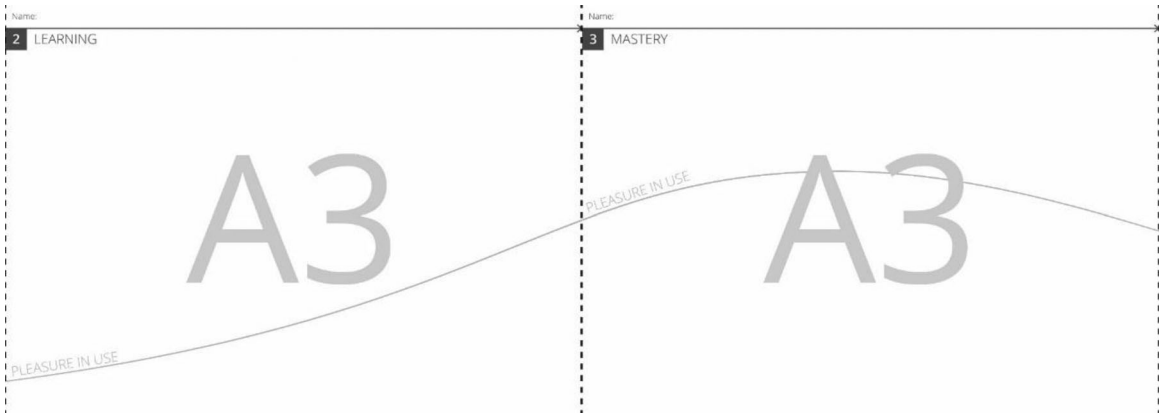

Figure 7. Example of A3 Sketch Papers (for Learning and Mastery phases) prepared for the workshops.

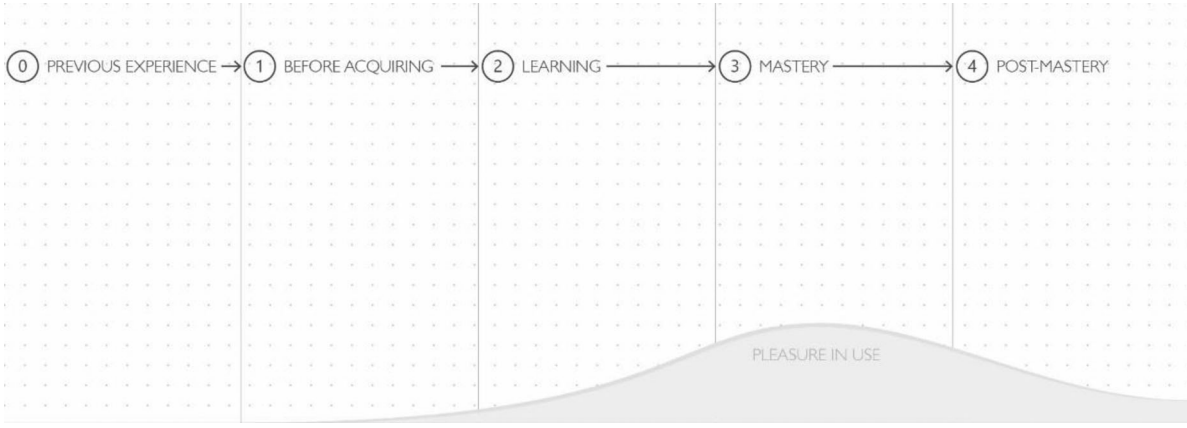

Figure 8. Example of Interview Notes Template for participants of Study 1.