Emotionally Sustainable Design Toolbox: A Card-Based Design Tool for Designing Products with an Extended Life Based on the User’s Emotional Needs

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Abstract: Emotionally sustainable design helps users to develop an emotional attachment to a product and motivates them to continue using it, thus extending the product lifecycle, minimizing the need for new products and achieving product sustainability. However, the existing relevant design principles are still very scattered, and they could not effectively guide the emotionally sustainable design practice in a systematic way. We proposed an emotionally sustainable design (ESD) toolbox for product design based on the literature review and expert argumentation. The toolbox consists of seven themes and 20 principles under the three levels of emotional design. The usability of the ESD toolbox was then validated through design practice for the teapot product. The result shows that the ESD toolbox improved the efficiency of the sustainable design process and was helpful to the product’s sustainability.

Keywords: emotionally sustainable design; product design; emotional design; ESD toolbox

1. Introduction

The goal of sustainable development involves different dimensions such as environmental, social, and economic [1]. Of these, environmental sustainability is the most widely studied area [2], and product design is critical to addressing environmental sustainability. The product design stage determined an estimated 80% of sustainability impacts. Therefore, better design has considerable potential to reduce the product’s environmental impact [3]. At present, the focus of sustainable design is shifting from single products to complex systems [4]. The emerging product service systems [5] and systemic design [6] could be helpful in reducing product waste, but they cannot influence consumer waste behavior at the root [7]. For product sustainability, how to extend the product life cycle to minimize demands for new products is still a question that deserves continuous academic attention. Many researchers have noted an increasingly apparent trend that products are being thrown away not because they lack physical durability but because consumers have lost their emotional attachment to the products [8]. Given that the positive emotions a product conveys to the user are associated with more frequent use of the product, researchers have proposed various theories to explore the relationship between design and emotion [9,10]. For example, Chapman proposed a method to extend the life of a product by enhancing the emotion between the user and the product, called emotionally durable design (EDD) [11].

In the long run, EDD may be the solution to creating a strong emotional attachment and resonance between people and products. However, existing frameworks and strategies for EDD are not able to effectively support designers’ consideration of emotional sustainability in design practice. On the one hand, emotionally sustainable design, in particular, should take a people-oriented approach. To be effective in practice, the existing toolboxes for emotionally sustainable design must address the pending challenge of how to cater to...
users’ emotional needs. On the other hand, while extant research on emotional durability proposed a number of design frameworks and strategies [7,12–14], they are either too abstract to be used directly or only target a single product, and, therefore, cannot be applied generally.

To deal with these issues, we attempted to develop an emotionally sustainable design (ESD) toolbox for emotional design by reviewing the literature on emotional sustainability and holding expert seminars. As card-based methods are better suited to design practice than other media, the final toolbox is presented in the form of design cards. Finally, we simulated the application of the toolbox in the actual product development processes with design thinking.

This paper extends the extant literature concerning the following aspects. Firstly, this paper proposes a toolbox for emotionally sustainable design, using the three levels of emotional design as a framework to provide new ideas for the study of emotionally sustainable products. Secondly, the proposed ESD toolbox is presented in the form of design cards, which enrich the application of design cards in the specific field of sustainable design. Finally, we attempted to use the toolbox for guiding design practices. The approach of integrating design principles into the design thinking process offers a new perspective for the question of how the ESD toolbox could be used to guide design in practice.

The following sections are structured as follows. The second section provides a literature review. The design process with the ESD toolbox is presented in Section 3. Section 4 describes the ESD toolbox in detail. Section 5 demonstrates a design thinking practice with the toolbox and shows the final design results. Section 6 discusses the present study, and the last section concludes the study.

2. Related Works

2.1. Card-Based Methods

In the 21st century, there has been a boom in card design, and to date, there have been many card-based design tools, for example, IDEO cards or Design Heuristics cards, and some researchers have argued that card-based tools are superior to other media in terms of design [15]. Cards provide a medium for physical manipulation and can facilitate interactive communication and shared understanding. Existing categories of cards include cards that provide prompts to stimulate creative thinking [16,17]; cards that summarize good design practice, know-how, or information [18]; cards that summarize design methods [19]; cards that provide concepts for specific design problems or domains [20]; and cards that provide checklists to aid specific design tasks. However, the number of card tools developed based on sustainable design, especially emotionally sustainable design, is still relatively low [21].

2.2. Sustainable Product Design

Sustainable product design focuses on improving the product life cycle through design, thereby solving problems encountered in economic and social development, such as environmental pollution and resource waste [22]. Sustainable product design has been identified as a key tool in coping with the global sustainable development challenges. It has evolved into an important method of product development [23].

Researchers have proposed a variety of solutions to make products sustainable. Green design [24] and ecological design [25] introduce environmental factors into the design, design for extended product life and durability focuses on the physical properties of the product itself [26], and sustainable behavior design [27] and social responsibility design [28] focus on the impact of user behavior on products. However, in practice, designers still shy away from these methods. The defects of these methods themselves can only partially explain the low adoption rate. More importantly, users have increasingly high emotional expectations for products. However, most sustainable design approaches ignore emotional factors in the first place, depriving the users of emotional connection with the products
and thus making it difficult to attract users who wish to buy the products or use them for a long time.

2.3. Emotional Product Design

Over the past three decades, as consumers became increasingly savvy about their emotional experiences with products, studies in emotional design have proliferated. Among them, the greatest number of studies have focused on Kansei engineering, which aims to conduct a qualitative and quantitative examination of the psychology of people’s sensory responses to products by employing engineering technology, thereby designing products that can reflect users’ feelings rather accurately [29]. Jordan’s product pleasure model focuses on the process of interacting with the product [30]. McCarthy and Wright’s framework of user experience considers the user’s overall experience in terms of four core threads: sensory, emotion, composition, and spatial–temporal fusion [31], and Desmet Pieter’s human-centered design theory model focuses on the role of products on experience and behavior on well-being [32]. These models can help designers think about how a product’s properties and interactions with the product can bring different kinds of pleasure to the user. However, compared with Norman’s emotional model, they could not fully explain how the pleasurable experience occurs. Norman’s emotional model describes how a user’s emotions and behaviors are determined by the brain. This model divides the brain’s regulation of emotion into three layers: visceral, behavioral, and reflective [33]. The emotional design considers the full range of human emotional experiences in various environments. The visceral layer reflects the user’s first impression of the design and requires the product to match the user’s aesthetic interests; the behavioral layer refers to the user’s emotional experience brought by the product’s operability, focusing on the pleasure brought by the product’s usability; the reflective layer is the highest level of emotional products, mainly referring to the user’s understanding and reflection of the meaning contained in the product and its usage, which reflects the attractiveness and satisfaction brought by the integrated design.

The ESD toolbox proposed in this paper builds on Norman’s emotional design model and classifies the product-generated emotional experiences across the visceral, behavioral, and reflective levels. This framework can help designers to be more ‘people-oriented’ and fully consider the emotional needs of users.

2.4. Emotionally Sustainable Product Design

2.4.1. Emotionally Durable Design (EDD)

EDD aims to establish a strong emotional connection between products and users at the spiritual level, such as enhancing the added value of products and evoking the emotional memories of users [11]. EDD pays close attention to the interaction between the product and user and depends on a good user experience to generate the user’s emotional attachment to the product. Therefore, EDD emphasizes that in order to better integrate product functions and user emotions, the designer should not only consider the user’s first-time feelings while using the product but also pay attention to the balance between its later functional variability and stability. By reconstructing and combining various EDD theories, researchers have proposed relevant design principles [13], which have been validated by case studies [14]. However, these principles are still too abstract to be used directly by designers. Haines-Gadd et al. proposed 38 strategies under nine themes through a series of seminars [7] aimed at implementing emotionally sustainable design in lighting design. However, they failed to form a universal emotionally sustainable design toolbox.

2.4.2. Product Attachment

Product attachment can be defined as the user’s experience of special and important items [34]. A person’s attachment to a product leads the user to adopt more protective behavior toward the product. For example, when a product is unique to the user because it carries a precious memory, the user will take good care of the product. Thus, one
possible strategy for extending the product life cycle is to increase people’s experience of
attachment to the products they use and own. The key premise for using an attachment
to build a lasting relationship is that the user feels that the product is irreplaceable, and
this can only be achieved if the meaning of the product is deeply anchored in a particular
product. To make a product irreplaceable, the designer can stimulate the formation of
product-related memories of the user or create unique personal products [35]. Cultivating
product attachment is a challenge for designers. Many theories of product attachment are
mainly applicable to unique customized products or art-oriented products [11,36], while
few studies exist on how to apply these theories to everyday products [37].

2.4.3. Other Theories

There are other theories related to emotional sustainability include product metaphor [38],
symbolic meaning of products [39], and slow design [40]. Paul Hekkert defined a product
metaphor as “any kind of product whose design intentionally references the physical
properties (e.g., form, sound, movement, smell, and so on) of another entity” [41]. Designers
can achieve instrumental and functional product goals through metaphors or provide users
with aesthetic, semantic, sensory, or emotional experience [42]. Products gain symbolic
meaning when people associate them with experiences, people, places, or ideas that are
meaningful or relevant [43]. Users can encourage, preserve, and prolong meaningful life
experiences through symbolic products. In addition, these products can remind people
of these experiences and help people relive and share them [44]. Slow design seeks to do
everything at the right speed. The researchers fine-tuned and refocused Fuadluke’s six
principles of slow design [45], while also introducing a seventh principle: ‘ritual’ [39].

Emotionally durable design and product attachment theory attempt to make products
connect with users on a spiritual level. Slow design focuses on the process of product
interaction with the user. Product metaphor and symbolic meaning are similar; both of
them can help users form an attachment to the product through ideological expression so
as to achieve long-term retention of the product. However, the existing relevant design
principles are still very scattered, and they could not effectively guide the emotionally
sustainable design practice in a systematic way. Therefore, relevant design principles need
to be integrated and classified to develop an appropriate ESD toolbox.

3. Method

In this section, we describe the development process of the ESD toolbox. As shown in
Figure 1, we first systematized the literature on emotionally sustainable product design,
collecting and sorting out the relevant design principles. Then, in the process of analyzing
and categorizing the design principles, we proposed a rough framework for the toolbox
in conjunction with a model of emotional design. Finally, we organized a workshop with
experts and designers in the field of sustainability research and emotional design to refine
the framework and propose the final ESD toolbox.

![Figure 1. Flow chart of the development process of ESD toolbox.](image-url)
3.1. Early Framework of Concepts

We performed a literature review to form the first iteration of the emotionally sustainable product framework comprising normative and clear design principles of product ESD. The first step was summarizing extant theories on sustainable design and presenting them in Table 1. Table 1 consolidates different design strategies proposed by prior research on product sustainability, especially product emotional sustainability. Among them, most of the strategies emphasize the establishment of a close relationship between the product and the user, especially the emotional attachment of the user to the product.

| Theories | Strategies | Sources |
|----------|------------|---------|
| Sustainable product design | Reliability and robustness; repair and maintenance; upgradability; variability; product attachment | Nes, N.V.; Cramer J., 2005, [12] |
| | Appearance; materials selection; product efficiency; user experience | Lobos, A., 2014, [37] |
| | Assure reliability; enhance durability; develop attachment; customize to wants and needs of each person | Beguerisse, M.M.; Ponte, O.; Charnley, F., 2017, [46] |
| | High durability; easy maintenance; refurbished; adaptable to new functions; flexible design; personalized | Agost, M.J.; Vergara, M., 2020, [47] |
| Emotionally durable design (EDD) | Surface; users are enchanted by the product; attachment; detachment; consciousness; narrative | Chapman, J., 2009, [13] |
| | Involvement; rewarding; animacy; adapt to the user’s identity; evoke memories | Van Krieken, B.; Desmet, P.; Aliakseyeu, D.; and Mason, J., 2012, [14] |
| | Imagination; integrity; materiality; evolvability; identity; narratives; relationships | Haines-Gadd, M.; Chapman, J.; Lloyd, P.; Mason, J.; Aliakseyeu, D., 2018, [7] |
| Product Attachment | Evoke enjoyment; memories | Schifferstein, H.N.J.; Zwartkruis-Pelgrim, E.P.H., 2008, [48] |
| | Pleasure; self-expression; memories; group affiliation | Mugge, R. 2008 [39] |
| | Experiencing physical contact; individual’s value and ideology; memories to person, place and event; experiencing enjoyment with others | Ko, K.K.; Ward, S.J.; Ramirez, M.J., 2011, [6] |
| | Aficionado-appeal; rarity | Jung, H.; Bardzell, S.; Blevis, E.; Pierce, J.; Stolterman, E., 2013, [49] |
| | Pleasure; reliability; usability; adaptability; memories | Page, T. 2014 [34] |
| Product Metaphor & Symbolic meaning of products & Slow design | Reveal; expand; evolve; participate; reflect; engage | Strauss, C.; Fuadluke, A., 2008, [45] |
| | Reveal; expand; evolve; participate; reflect; engage; ritual | Grosse-Hering, B.; Mason, J.; Aliakseyeu, D.; Bakker, C.; Desmet, P., 2013, [40] |
| | Pleasure; intimacy; aspiration; self-image; memory; belonging | Ko, C.H., 2017, [42] |
| | Environmental mastery; autonomy; self-acceptance; personal growth; positive relations with others; purpose in life | Casais, M.; Mugge, R.; Desmet, P., 2018, [43] |
| | Incorporating significant memories and associations | Orth, D.; Thurgood, C.; van den Hoven, E., 2018, [36] |
| | Increasing sensory variety; aging well; maintenance quality; exclusivity; pre-purchase personalization; making social connections | Haug, A., 2018, [50] |
Next, we classified and clustered the design principles in Table 1. First, a visual auxiliary tool that called conceptual mapping was used to reorganize and appropriately combine each principle. Second, through the affinity graph, we studied the relationship between the principles and crystallized and clustered the principles in the study. According to Norman’s emotional design theory, users’ emotional needs and expectations for products may come from different levels. Therefore, to help designers better understand the emotional needs of users, we have summarized the design principles using the three levels of emotive design as a broad framework based on Norman’s definition of each level [33] and with reference to existing examples of emotive design products [51].

After the attribution, although the existing concepts were classified into different themes and strategies in the broad framework of emotional design, it was still a rough framework that needs to be refined and improved through an expert seminar.

3.2. Improving the Toolbox

We recruited sustainable development experts and designers to hold a seminar to iterate and refine the toolbox. The experts are five professors from Zhejiang University and Zhejiang University of technology in China, who have in-depth research on emotional product design and sustainable design.

The researcher first provides a detailed introduction to the three levels of emotional design and provides examples of product design at different levels to ensure that the experts fully understand the different levels of emotional design. The researcher then explains the themes and principles that promote emotionally sustainable product design under each level.

The seminar was held to inform the experts about the design principles and demonstrate how they can be embodied in the design, ensuring that these principles were easy to understand and could help designers in ESD. Furthermore, in the seminar, experts were required to discuss the themes and strategies to improve and enrich the principles in the toolbox. The seminar was held in two rounds over two months, with five experts in each round. Throughout the process, researchers acted as a facilitator to encourage experts to express their understanding of the concepts and the framework.

3.2.1. Process of the Seminar

Each round of the seminar was divided into two sessions. In the first session, experts were to understand and familiarize themselves with the conceptual design principles. We prepared several cards for the design principles. Figure 2a shows the conceptual design principles. The researcher introduced the principles to the experts and explained how they could be applied in design practices. For each design principle, experts were asked to consider two questions:

- Do I understand the design principle well with the existing description?
- Does this principle help me design emotionally sustainable products?

![Figure 2. (a) Concept cards; (b) experts in the seminar; (c) concept cards with pictures.](image-url)
After the introduction of each design principle, experts were asked to present relevant product design cases that were in line with the design principle. The case could be an existing product or an idea, expressed orally or in sketches. The researcher would record the relevant product cases presented by the experts to prepare for the next session, as shown in Figure 2b. The activity helped the researcher to evaluate whether experts had understood the design principles correctly and enhanced each expert’s understanding of the design principles. Meanwhile, it allowed experts to question the definition of a design principle and to state their different views of the principle to provoke discussion.

The second session would start when it was certain that each expert had fully understood each design principle and had no objection to it. In this session, the experts were required to think about whether each principle was consistent with its theme and whether it could solve the design issues at the corresponding level of the emotional design framework. The researcher first provides a detailed introduction to the three levels of emotional design and provides examples of product design at different levels to ensure that the experts fully understand the different levels of emotional design. The researcher then explains the themes and principles that promote emotionally sustainable product design under each level. Experts discussed the themes and framework of the design principles with reference to their own product cases presented in the first session. In this session, the main questions to be answered by experts were as follows:

- Which of the three levels of product experience does this design principle address?
- The product case proposed in response to this principle leads to a better product experience at which level or levels of the three levels?

### 3.2.2. Results of the Seminar

The researcher recorded all feedback and thoughts of the experts as the basis for further iterations of the design toolbox. Over the course of the seminar, it was discovered that participants needed emotionally sustainable product design examples to better understand and apply the principles. Until these examples were provided, the interpretation of the principles might vary from person to person. Therefore, on the basis of the meaning of the principles themselves and the comments of the experts during the discussion, we added a more relevant example of product design to each principle, which was depicted by a sketch on the tool card, as showed in Figure 2c.

Finally, we developed the toolbox for emotionally sustainable products based on the results of the two rounds of the seminar. Table 2 shows the principles in the toolbox. We will discuss in detail in the next section each design principle in the toolbox.

| 3 Levels | 7 Themes | 20 Principles | 20 Examples |
|----------|----------|---------------|-------------|
| Visceral | Pleasure | Aesthetic design [7,8,13,34,35,42,43,50] | ![Aesthetic design](image) |
|          |          | Surprise [7,14,43] | ![Surprise](image) |
| Behavioral | Integrity | Usability [12,34,46,47] | ![Usability](image) |
|          |          | Visualization [40,45] | ![Visualization](image) |
|          | Adaptability | Repair and maintenance [12,34,46,50] | ![Repair and maintenance](image) |

Table 2. Toolbox for emotionally sustainable products.
Table 2. Cont.

| 3 Levels       | 7 Themes        | 20 Principles       | 20 Examples       |
|----------------|-----------------|---------------------|-------------------|
| Memory         | Narrative       | Aging well [13,50]  |                    |
|                |                  | Flexible design [12,47] |                  |
| Reflective     | Development     | Consciousness [7,13,14] |                |
| Intimacy       | [7,12,13,42,49] | Ritual [40]        |                  |
|                |                  | Aspiration [7,14,42] |                  |
|                | Evolvability    | Reflection [7,14,40,42,45,47,49,50] |              |
|                |                  | Self-expression [35,43] |                |
|                |                  | Engagement [40,45]  |                  |
|                | Engaged         | Narrative [7,13,34,35,42] |            |
|                |                  | Participation [40,45] |                  |
|                | Engaged         | Helping form memories [8,14,36] |             |
|                |                  | Belonging [35,42]   |                  |
|                |                  | Making social connections [8,50] |            |
4. Introduction of the ESD Toolbox

We proposed an ESD toolbox for product design based on the literature review and expert argumentation. The toolbox consists of seven themes and 20 principles under the three levels of emotional design, see Supplementary Material for details.

4.1. Visceral Level

Visceral level means the initial physical sensations of a person’s vision, hearing, touch, taste, and smell to a product’s physical properties, including product appearance, structure, material, and color. In other words, it refers to the immediate sensory reaction to the product and its first impression in the person’s mind. The pleasure of the product definitely belongs to this level.

Pleasure

- **Aesthetic design**: The enjoyment and pleasure a product brings to users is the main driving force for the emotional sustainability of the product. Designing a product that evokes pleasure first requires it to evoke sensory and aesthetic pleasure. Among these, the visual and tactile experience of the product is considered to be the most effective in evoking user enjoyment. Therefore, it is a good design method to design products with a good user experience in terms of vision and touch.

- **Surprise**: Users will soon get used to the fresh and pleasant feeling conveyed by the product, which is called ‘hedonic adaptation’. Emotionally sustainable products need to evoke users’ pleasant experiences frequently—perhaps even different emotional experiences frequently—thereby trying to avoid users’ hedonic adaptation. Therefore, the task of the designer is to incorporate surprise into the product, to keep the product stimulating and engaging the user, and to create a sense of surprise and mystery for the user.

4.2. Behavioral Level

Behavioral level focuses on providing a pleasurable experience while the user is using the product. Product integrity and adaptability will directly affect the experience of using the product, so they belong to the category of the behavioral level.

4.2.1. Integrity

- **Usability**: In his attachment framework, Norman emphasized the importance of usability in the relationship between consumers and products and suggested that the usability of products affects the enjoyment and pleasure of users using products. Therefore, there is no doubt that the usability of the product affects the experience of using it. Many factors affect the usability of a product, including product durability and quality. Durability and high quality are not only the physical premise for longer-lived products but also allow users to become emotionally dependent on the products over time and realize the emotional sustainability of the products.

- **Visualization**: Visualization requires designers to pay attention to something that may be ignored or unnoticed by the user while using the product, including the details of the product and the invisible experience during usage, and visualize these details and experience well. For example, the product shell could be designed to be transparent to show the internal structure of the product when it works or to visualize the passage of time so that users are aware of the progress of time. Good visualization can improve product integrity, realizing a smoother user experience and enhancing users’ sense of experiencing the product.

4.2.2. Adaptability

- **Repair and maintenance**: A product that is easy to maintain and repair is more reliable because the user can use it for a long time. In addition, products repaired by the users themselves are usually endowed with new emotions, giving the users a
stronger sense of connection to the products. For easy maintenance, the product repair operation must be very simple, so that users can do it themselves. A good approach is to provide a modular design that simplifies maintenance to replacing modules.

- **Aging well**: The product changes and increased usage over time could form tangible physical features that improve usability. Aging well is different from product durability and high quality. The process by which the product changes over time can make the user feel as if the user is accompanying the product and helping the product evolve, thereby facilitating product attachment. For example, the tea deposits in a Zisha teapot are believed to be the result of wear over time and the user’s emotion.

- **Flexible design**: Form flexibility is concerned with providing the user with the possibility of alternative forms of the product without the need to add parts. The product can take several forms, with different use scenarios or different functions along with the growth of the user, or can also be completely user-determined, usually through modular component design.

### 4.3. Reflective Level

The reflective level refers to deeper emotions generated in the user’s mind due to the action of the first two levels. It is a complex emotion involving the product and the user’s consciousness, experience, and culture. A sense of connection to the product, a sense of personal significance, great memories, and positive social relationships are all experienced at this level.

#### 4.3.1. Develop Attachment

- **Consciousness**: If a product is perceived as autonomous, as having its own free will, it can significantly enhance the sense of connection between the product and the user. The products can be ‘weird’, often ‘moody’, and even require users to learn how to ‘communicate’ with them. This makes the interaction between the user and the product more interesting and enriches the user experience. When designing the way the product interacts with the user, the designer could imitate animal or human behavior to realize the autonomy of the product.

- **Intimacy**: If a user can develop a sense of intimacy with the product, there is no doubt that the user will become attached to the product, enhancing the emotional sustainability of the product. Building a close relationship with the user could be achieved by designing features that need to be used regularly. When a user needs to rely on the functions of the product to perform routine tasks, regular use of the product could be ensured. Frequent use of the product can build a high level of intimacy with the product.

- **Ritual**: A sense of ritual can lead to a great user experience, creating a ritual or habit that makes the product an important part of the user’s life. Designers can design special use methods according to the function of the product to form a sense of ritual or can directly design products that can help to create a sense of ritual atmosphere, such as enhancing lighting effect or a special scent.

- **Aspiration**: Product attachment and emotional persistence may occur when a user has positive expectations about using a product. This makes the user want to use the product by reflecting the user’s success or communicating the user’s social status, such as designing high-quality products or rewarding the user for using the product. Mutual altruism can support a relationship with the product.

#### 4.3.2. Individual’s Value

- **Evolvability**: “Helping users grow” focuses on the long-term changes the product brings to the user, in the hope that users will learn some skills or create something to grow themselves over the long term. For example, long-term use of fitness equipment will help users to get a good figure, and long-term use of musical instruments will
help users to acquire a skill. The product will witness the growth of the user. The process of self-growth is also the process of establishing a connection with the product.

- **Self-expression**: People use products to express themselves, and, therefore, products must adapt to the identity of the users. If a product is used to define and maintain a person’s personal identity, the product takes on special significance to the user. Self-expression focuses on the use of products to express a user’s personality or particular group identity, such as using environment-friendly bags to express the user’s identity as an environmentalist.

- **Reflection**: A product that triggers reflection can lead to a deeper emotional experience, which increases the chances that users will keep the product longer. What designers need to do is not ask users questions in a blunt way but make users stop and think about a profound question related to the meaning of their lives through clever metaphors in combination with the functions of the product so as to help users live a better life.

- **Engagement**: Users participate in the design and become designers. The more actively users participate in the design process, the more likely they are to have a stronger emotional attachment to the product they designed. This requires designers to stimulate the user’s desire to participate in the design through an unfinished product. Moreover, it is best to provide design references as far as possible to help users to create their own satisfactory design.

4.3.3. Memory

- **Narrative**: When a product carries more or stronger memories, users are more likely to keep the product for longer. In this case, the product can be used to recall the happy past and induce previous feelings of happiness. Designers can design nostalgic products, using the metaphor of products to achieve the recurrence of memory, or a special memory of the giver or recipient can also be attached to the product in the form of a gift.

- **Participation**: Participation in interaction refers to encouraging users to participate in the interaction with the product, thereby promoting the formation of special memories between the product and the user, so as to realize the emotional sustainability of the product. Through modularization, users can perform module changes to alter and interact with the product. This differs from users’ engagement in design in that participation in interaction provides not a semi-finished product but a complete product, taking advantage of the reinvention of the product to attract users to interact with it.

- **Helping form memories**: Products help users form memories of people, places, and events, while also making connections to important memories. Unlike shared memories, ‘product-assisted memories’ focus on helping users create and preserve memories, not just recall them. Products can be designed to help capture and reproduce the moment, or from the perspective of making memories, the designer can also design products that require group participation to help form memories of the people involved in the interaction or the interaction itself.

4.3.4. Positive Relations

- **Belonging**: Belonging is a product designed to support group affiliation, defining which group users belong to, and thus giving users a sense of belonging to a group. Instead of facilitating self-expression, designers design products to make users feel as if they are part of a group, rather than to reflect their identity. For example, products designed for a special social circle can make users feel that their social circle is significant and attracts attention.

- **Making social connections**: Social connection refers to helping users make social connections through the product. Encouraging users to engage in social activities and share experiences with others could help users build the desired personal connections
with family, friends, or social groups. By designing products needed for social activities, designers could encourage users to use the products with others, naturally taking part in social activities. Product metaphors can also be used to remind users to connect with others or engage in social activities.

5. Design Practices Based on the ESD Toolbox

Integrating the product ESD toolbox into the product development process will increase the toolbox’s value. Design thinking is based on a user-centered, practical approach to product development [52]. The process of design thinking gives the opportunity to experiment, create and prototype models, gather feedback, and redesign [53]. The subsequent section will therefore be conducted in a design thinking exercise for teapot products to verify the effectiveness of the ESD toolbox for design practice.

5.1. Design Thinking

In this stage, participants were required to design teapots with the ESD toolbox. The teapot was chosen as the object to be designed for the following reasons. First, it is a product that people use every day. Emotional sustainability is based on the premise that the user interacts with the product, so products for daily use are preferred. Second, the product should not be too complex, avoiding hindering participants’ creativity. Therefore, the teapot is an ideal candidate.

A total of 21 participants were recruited for the experiment, all of whom were design practitioners. The participants were given five hours to design a new teapot. All participants were given a set of design materials. They include a set of ESD cards, a clock for recording time, a set of colored post-it notes, several whiteboards, and an unlimited amount of white paper and brushes.

The experimental process was carried out in accordance with the five stages of design thinking defined by the D. School of Stanford University. The five stages are empathetic exploration, problem definition, ideation, prototype, and testing.

5.1.1. Empathy

Empathy is the basis for defining and solving problems [52]. Only by really understanding the potential needs of users could the designer find design opportunities. Considering the time and economic cost of the experiment, during the empathetic exploration stage, the researcher conveyed to the participants the emotional needs of the users, which had previously been collected through questionnaires and interviews, but the needs conveyed are unprocessed. Figure 3a shows participants analyzing and arranging user needs by referring to the three emotional levels of the toolbox. The process of analysis and arrangement can enable the participants to understand and digest the needs of users most rapidly.

5.1.2. Define

After fully understanding users’ requirements, the participants should identify the real problem to be solved according to the collected information. In the problem definition stage, participants were divided into seven groups, with three participants in each group, each of which was responsible for one of the seven themes to meet the emotional needs of users at the corresponding emotional design level. Each group defined the needs according to the theme they chose: for whom, to do what, and to solve which problem, as shown in Figure 3b. For example, for users who often use teapots, the group needs to design teapots that can convey a sense of pleasure, so as to solve problems such as dull and uninteresting teapots and enrich the visceral experience the teapot brings to the user. The seven themes of the toolbox can help to narrow the scope of the problems to ensure that the problems identified in the empathetic exploration stage are those that are really helpful in achieving emotional sustainability. On the other hand, they pinpointed the directions for subsequent ideation.
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5.1.3. Ideate
Once the problem is defined, designers can begin to solve the user problem. The specific principles of the toolbox can be fully used in this stage. Figure 3c shows that each group selected the corresponding design principles according to the theme identified in the problem definition stage to conceptualize and design the teapot. This process began with brainstorming within the group, in which group members boldly ideated design ideas. Subsequently, the group members need to further discuss and converge the previously ideated ideas and determine the unique teapot product under each design principle.

5.1.4. Prototype
The prototype stage requires the presentation of the teapot product that was identified in the ideation stage. Considering the duration of the experiment and the lack of material preparation, participants were not required to make prototypes. They only needed to draw a conceptual sketch of the teapot for each specific principle, as shown in Figure 3d.

5.1.5. Test Iteration
When the sketch was completed, each group was to appoint a member to present the designed teapot as showed in Figure 3e. Other groups rated the design on a scale of 1 to 10. The scoring criteria were mainly based on whether the teapot product met the requirements of the corresponding design principles and whether the teapot product could convey a better emotional experience so that people were more willing to retain and use it for longer.

5.2. Feedback and Reflection
After the teapot product design practice, we invited the participants to engage in a small discussion and asked them to think about the following questions:

- Was the product ESD toolbox helpful to the design process?
- Did the toolbox help you take the emotional needs of your users more into account?
- Did you feel you had a better understanding of emotional sustainability?
- What design principles from the toolbox did you think could help you better design your products?
The researcher observed and recorded the whole process of design practice and collected all feedback and reflections from the participants. Overall, the use of the toolbox improved the efficiency of the design process and the quality of the design outcomes. Most of the participants found the toolbox to be very helpful to their design process. They mentioned during the discussion that the design principles in the toolbox helped the team to quickly identify the problems that needed to be solved and to clarify the focus of the design. In addition, the design examples provided on the cards in the toolbox helped the participants to expand their ideas and develop their design creativity. In short, the use of the toolbox greatly enhanced the efficiency of the design process. On the other hand, the participants were satisfied with the results of the design practice, i.e., the creative design of the teapot. In particular, the majority of the participants were very satisfied with the designs that were guided by the corresponding design principles. For example, a teapot based on ‘narrative’, which shows the last interaction with a friend, and a teapot based on ‘making social connections’, which allows the user to interact with others during the tea making process, etc., were all rated highly during the ‘test iteration’ phase. The majority of the participants felt that the ESD toolbox allowed them to focus on user’s emotions in the design process, which they had not previously focused on, and improved the quality of their designs.

In addition, some participants felt that the use of the toolbox gave them a better understanding of emotionally sustainable design, which the researchers had not previously envisaged. The participants suggested that during the test iteration, i.e., the evaluation of other people’s designs, they needed to understand each design principle carefully in order to have a more objective and accurate evaluation of other people’s designs. Thus, the participants gained a deeper understanding of each design principle in the process, which led to a better understanding of emotional sustainability.

5.3. Presentation of the Design

Table 3 presents the designs of each group in the design exercise according to relevant design principles. The researcher has redrawn them for the sake of consistency and refinement.

| Aesthetic design | Surprise | Usability | Visualization |
|------------------|----------|-----------|---------------|
| ![Aesthetic design](image) | ![Surprise](image) | ![Usability](image) | ![Visualization](image) |
| This design is modeled by simulating an object to bring aesthetic enjoyment. | The different temperatures will lead to different and patterns each time the tea is made. | The teapot is made of a metal sheet. | The rotation scale can be used to set the tea-brewing time. |

| Repair and maintenance | Aging well | Flexible design | Consciousness |
|------------------------|-----------|-----------------|--------------|
| ![Repair and maintenance](image) | ![Aging well](image) | ![Flexible design](image) | ![Consciousness](image) |
| The design turns the teapot maintenance into a simple replacement action. | Each time the tea is made, it leaves a mark on the teapot, which can form a pattern similar to growth rings. | The lid of the teapot can be split to make a teacup. | The smart teapot can send regular invitations to friends. |

Table 3. Designs of each group in the design practice.
Table 3. Cont.

| Intimacy | Ritual | Aspiration | Evolvability |
|----------|--------|------------|--------------|
| ![Image](image1.png) | ![Image](image2.png) | ![Image](image3.png) | ![Image](image4.png) |
| The traveling teapot is designed to be carried around by the user. | Small ritual items are provided to add a ritual sense to the activity of drinking tea. | According to the different effects of the tea, the user will be reminded about the health effects. | It can help users acquire tea-related knowledge. |

| Participation | Help form memories | Belonging | Making social connections |
|---------------|-------------------|-----------|--------------------------|
| ![Image](image5.png) | ![Image](image6.png) | ![Image](image7.png) | ![Image](image8.png) |
| The teapot can record or take pictures, and its electronic screen can display the last time a friend interacted with the user. | The teapot can record or take pictures, and its electronic screen can display the last time a friend interacted with the user. | The teapot can record or take pictures, and its electronic screen can display the last time a friend interacted with the user. | The teapot can record or take pictures, and its electronic screen can display the last time a friend interacted with the user. |

6. Discussion

The final toolbox is presented in the form of design cards that facilitate communication and shared understanding among designers during the design process. The text in the cards explains the design principles in detail and illustrates relevant product design examples through images. The presentation of the toolbox cards not only provides designers with inspirational tools for designing emotionally sustainable products but also enriches the application of design cards in the specific field of sustainable design [21].

Prior research has proposed several design principles to guide designers in their design practices [7,12–14]. However, we believed that truly user-centered emotionally sustainable design should be produced under the framework of users’ emotional needs. Therefore, this paper attempted to develop an ESD toolbox based on emotional design. The proposed design principles were critically reviewed and iterated upon in a process of re-factoring, clustering, and organizing expert seminars on the theory. The usability of the ESD toolbox was then validated through design practice for the teapot product. On the one hand, based on the information gathered in the literature review and the
expert seminar, the principles involved in the toolbox will increase the possibility of forming product attachment. According to prior studies, this will extend the mental life of the product [11,34,35]. On the other hand, through the information collected in the design practice and the follow-up feedback of the participants, we knew that the application of the toolbox promoted the product’s sustainable process and was helpful to the product’s sustainability.

Over the course of several iterations of the ESD toolbox, we first introduced product integrity. Previous studies generally focused on the establishment of emotion while ignoring the usability of the product itself. However, based on the framework of emotional design, this paper suggested that the behavioral-level experience conveyed by the product is the foundation of reflective-level experience. In other words, the effects of the product’s functions and usability on product emotional sustainability could not be disregarded. This is also in line with sustainable ergonomics, which suggests that products that are easier to use make users feel more comfortable and enjoyable [54]. Second, the ‘rewarding’ was integrated into ‘aspiration’. In the initial literature review, we were not aware that the different granularity of the design principles proposed by extant research and the listed principles were not mutually exclusive. Rewarding actually explains how users are motivated to use a product. Therefore, we combined the two principles. Finally, both ‘adapt to the user’s identity’ and ‘rarity’ are classified into ‘self-expression’. Different users, even the same user using different products, may need self-expression from different levels, possibly identity, idea, or even ideology. Therefore, when considering how to let users express themselves through products, designers should ideate from different perspectives according to specific target users and products.

It should be noted that surprise at the visceral level is controversial. Indeed, the sense of surprise is not the surprise at the appearance at first sight. It refers to the excitement and surprise the users experience any time they use the product. However, according to the definition, the surprise was used to counter users’ hedonic adaptation of the product. The purpose of this principle is to seek the effect whereby users thought that they were facing a new product every time they used the product. Constant attraction is needed to bring users a rich imagination space. Therefore, ‘surprise’ was finally classified into the visceral level of emotional design.

### 6.1. Application of the Toolbox

Firstly, in terms of the people to apply it to, based on the results of design practice and user interviews, the toolbox proves to be a good aid to designers in designing emotionally sustainable products. The toolbox provided in this paper contains a detailed explanation of the design principles along with relevant cases, which greatly lower the threshold at which some participants reported in the interviews that they were able to understand each design principle quickly and that the information in the card toolbox helped them to refine and iterate on their ideas faster. In the follow-up interviews, most of the participants reported that they had a better understanding of emotionally sustainable design. Regarding applicable products, to reduce the unnecessary emotional burden of users, we should avoid attaching too much emotion to products that should be discarded as appropriate. We recommend that designers use the toolbox to design everyday products or public facilities that users frequently need to use.

Secondly, with regard to the way in which the toolbox can be used, each card can be used individually or in combination with others for a single product. In particular, it is definitely possible to embody the experience of the three levels of emotional design in one product. Although the participants were asked to design a teapot for a single principle in the course of the design practice, it was not difficult to see that many of the designs represented a combination of different design principles. An example of this is the teapot designed for the ‘reflection’ principle that the outer surface of the teapot will crack when the water overflows, prompting the users to reflect that ‘the moon waxes only to wane, and water surges only to overflow’. However, the process of prompting the reflection is
also a process of ‘surprise’ for the user, and the pattern formed by the water overflows is also an application of ‘visualization’. However, it is also not necessarily the case that the more principles are better for a product. For example, a seemingly self-conscious product that encourages users to interact with the product itself, to engage in social activities for building social connections, and constantly remind users to reflect will greatly increase the burden on users. The formation of product attachment requires the user to interact with the product. Whether the attachment can be generated still depends on the user’s culture, experience, and even values. Designers need to consider the real emotional needs of target users according to the attributes of the products to be designed and then choose the appropriate principles for the design.

Finally, the toolbox can also play a role in assessing the usability of emotionally sustainable products. Most previous research on emotional sustainability has been limited to proposing appropriate design principles, with little design practice, making it difficult to close the loop from design to validation. In this study, the product of design practice was initially tested in a simulated ‘test iteration’ process through a design thinking process. The process of evaluating other people’s designs using the design principles in the toolbox demonstrates the potential of using the toolbox to assess the usability of emotionally sustainable products.

6.2. Research Limitations and Future Opportunities

First, the purpose of the research is to integrate the existing principles of sustainability and develop a product ESD toolbox guided by users’ emotional needs. Considering that the newly proposed design principles have not been verified in practice and their reliability cannot be guaranteed, the design principles in the current toolbox are all derived from previous studies. On the basis of current research, future studies could propose new design principles and put them into practice to evaluate whether they are really suitable for designing emotionally sustainable products.

Second, in the present study, the framework of the emotional design was used to summarize the design principles. Future research can try to integrate more emotional frameworks, such as self-determination theory and Maslow’s hierarchy of needs theory, to strengthen the theoretical support of the toolbox.

Finally, current research focuses on the sustainable use of products by designing products that better meet the emotional needs of users and reduce consumer discard behavior, thus allowing consumers to keep products for longer. The goal of sustainable development has different environmental, social, and economic dimensions [1]. Future research therefore considers expanding the toolbox at the process and paradigm levels to achieve the goal of social sustainability [55]. It is hoped that through the use of the toolbox, designers will be able to design products that have less negative impact on social systems and contribute to sustainable development in a more holistic way.

7. Conclusions

The paper builds a product ESD toolbox through a literature review and expert argumentation on the emotional design framework for meeting users’ emotional needs. The ESD toolbox can be used not only to guide the design of emotionally sustainable products but also to verify whether the existing product has the characteristics of emotional sustainability. In addition, the ESD toolbox enriches the application of design cards in the specific field of sustainable design. In summary, the ESD toolbox closes the loop from sustainable product design to sustainable product verification.

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