Designing Unique Products with Self-morphing Randomness

Kyunghyun Kim[1], Tek-Jin Nam[1]

[1] Department of Industrial Design, KAIST, Daejeon, Korea

Background As people's needs for differentiation and identity are changing, it is necessary to search for alternatives to standardized mass production in product design. To overcome limitations of existing approaches, we investigated design methods applying randomness for designing unique products.

Methods Three research methods were adopted. First, to understand the nature of randomness in order to build a theoretical basis, we reviewed related works dealing with randomness in the art and design fields. Second, we proposed self-morphing randomness as a method for product and service system design. We also developed three design cases. Third, we evaluated the feasibility and impact of the proposed method through expert and focus group interviews.

Results Self-morphing randomness is a design method whereby functional fundamentals of a product are randomly used to create unique products. To show the feasibility in the design practice, we developed three products using the method: Light-morph-Light lamp, Light-print-Light lamp, and Sound-print-Sound speaker. Through expert and user evaluation, we identified that self-morphing randomness offers value in terms of uniqueness, spontaneity, storytelling, and emotional experience.

Conclusion This paper presents opportunities for applying randomness in designing unique products as an alternative for mass production. As a new design method, self-morphing randomness can help design practice and education. Products made using this method can contribute to satisfying customers' needs for differentiation and the pursuit of identity.

Keywords Self-morphing randomness, unique product design, design by use, product differentiation, recursive design

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Corresponding author: Tek-Jin Nam (tjnam@kaist.ac.kr)

1. Introduction

Recently, as the demand for differentiation and the diversity of people is increasing, the balance between designing unique products and satisfying customers has become an important research topic. Tian, Bearden, and Hunter (2001) claimed that tendency is increasing for consumers to try to enhance personal and social identity by purchasing products to differentiate themselves from others. As Till (2012) asserted, the market is changing its pattern for diversified production. mass customization, small quantity but large variety item production, and unique product manufacturing have gained attention as a response and alternative production method to mass production. (Hvam, Mortensen, and Riis, 2003). Mass customization is a method of producing products based on the needs of diverse consumers. It is done by enabling user customization upon ordering (Pine, 1999). However, it is a system available only to large, wealthy companies. Small-quantity manufacturing of various products has only been applied for special purposes, such as for marketing promotion (Balachander and Stock, 2009). Unique products are rather common in the arts and crafts market but have limitations in terms of price competiveness and low efficiency in production.

We investigated a design method applying randomness to meet the requirement of differentiation and diversity of customer needs. Randomness has been a concept actively employed by many artists in the past (Bateson, 1979). Recently its value has been gaining attention in design field. (Till, 2012). The reason our study tries to look at randomness is threefold. First, randomness has a tendency to contain unique values of beauty. This is recognized by many researchers. For example, Arnheim (1974) commented that compositional unity is made by the confliction between ideologically perfect simplicity and ultimate chaos. Secondly, randomness has been perceived as an origin of diversity and imagination. Artists have recognized the characteristics that stimulate imagination are triggered by randomness and have utilized them in multiple ways (Leong, Howard, and Verter, 2008). Finally, randomness provides new opportunities for discovery-oriented design.

Discovery-oriented design takes an open-ended approach without a clear image of the final outcome in the early stage of processes (Diaz, 2011). Randomness enables the open-ended process and makes it possible to obtain diverse design results (Brody, 2011).

Our aim was to investigate a method of applying randomness to design unique products in the field of product and system design. We also aimed to examine the method's value and the possibility of commercial realization. To achieve these aims, as the first step, we reviewed and analyzed diverse cases of randomness applied to related fields. This became the theoretical basis to understand the nature of randomness and application cases. In the second stage, we proposed self-morphing randomness as a design method of applying randomness to product and system design. This is a design method to realize the final state of a product by using fundamental characteristics of the product as variables of unique and random aspects of the product feature. The process can be categorized as process of product maturity or cultivation, for it utilizes self-morphing of product characteristics in making the final product. Through designing three product cases, we show how this method can be applied to actual design practice and how it can be made available as a service to both consumers and producers. In the third stage, we conducted focus group interviews with potential end users and in-depth interviews with experts. This was to understand the value and new opportunities for the proposed method.

2. Understanding Randomness and Related Works

2.1. Definition of Randomness

Randomness is defined as something that does not depend upon cause and effect (National Korean Institute, 2014). In modern art, randomness is understood as a characteristic in which diverse results are produced through deviation from control of the producer in a constrained frame (Pierre, 1975). We were inspired that randomness can be a creative means. Based on the previous definitions and the inspiration, we can define randomness as the characteristics of the process or the outcome that was acquired from indeterminacy intention.

2.2. Characteristics and values of randomness

Brody (2011) claimed that randomness may contribute to evolution of design. Drew, and Haahr (2002) have analyzed cases applying randomness in art and design and suggested obtainable values. They asserted that randomness is used to acquire inspiration for creativity, and that it can be a tool to transmit philosophical messages about the role of artists.

Eckersley (1990) studied the aesthetic possibility of randomness by analyzing the visual effects randomness provides. Whipple (1968) did experimental projects in which pictures with mathematical rules were created to see if non-intentional arts utilized by the randomness principle could create any aestheticism. Art referred to as stochastic paintings have interesting elements because they are unpredictable. Visual elements completed in random arrangements can produce diverse results because they show big differences, even with small parameter changes. This suggests that randomness can be a creative stimulus. Eckersley (1990) and Leong et al. (2006; 2008) investigated application methods of randomness in the interaction design field of digital systems. They pointed out that randomness provides fun and refreshing mood due to its unpredictable character in interaction. Also, they asserted that such randomness offers a young and free impression compared to fixed interaction.

Existing study results show diverse characteristics and value in art and design works to which randomness is applied. Design with randomness features deliver uniqueness and spontaneity due to the factor of its unpredictable character. This can present unexpectedly enjoyable serendipity to users. Also, users may feel self-confidence and pride in owning the unique product (Leong et al., 2006). Meanwhile, designers can add the value of storytelling, which enriches products. This aspect can highlight the identity of a product (JOH & Company, 2011). Also, randomness can be a source of creativity by its inherent nature (Whipple, 1968)

2.3. Examples of randomness applied to art

Artists have utilized randomness as a creative method to discover new ideas that are not intended by producers (Bateson, 1979; Diaz, 2011). Examples include the "Lessons" poem series by Samuel Beckett, the aleatory music of John Cage, and collage works of Hans Arp. In the field of arts and design, randomness is available as a tool to provide new experience. It is way of non-intentional control. Recently in the field of interaction design, randomness is used to provide diversity and new user experiences (Leong et al., 2006). For example, the arbitrary document searching function on Wikipedia shows random results. The shuffle function is an example of randomness applied to the music interface.

2.4. Utilization of randomness in design

Related works in the design domain can be divided into four groups: design using randomness to provide a new experience, graphic design seeking new beauty through digital randomness, 3D programming design seeking creativity, and analogue designs emphasizing uniqueness.

(1) Design using randomness to provide a new experience

Randomness has been utilized for providing freshness and new experience to users through unpredictable characteristics. The product of "the Something Store" delivered at random base enables customers to feel surprise and delight (Leong et al., 2008). Apple's campaign of "Life is Random" constitutes a new brand image connecting spontaneous randomness to a young and free style image (Leong et al., 2006).

(2) Graphic design seeking new beauty through digital randomness

To examine the potential of randomness on aesthetics, cases of visual programming have been introduced. Tony Scott's Glitch is a collection of works in which computer errors are transformed into artistic images. In this work, only frames are made in the beginning. Incidental visual information images are deviated from artist's control (Joachim, 2005).

(3) 3D programming design seeking creativity

Chaudhuri and Koltun (2010) observed that computer modeling involved a creative process and researched the possibilities of methods for applying randomness to support creativity in 3D modeling. Kalogerakis, Chaudhuri, Koller, and Koltun (2012) studied composing the new forms as assemblies of the cases through the probabilistic model. Similarly, Xu, Zhang, Cohen-Or, and Chen (2012) proposed a model of evolution.

(4) Analogue designs emphasizing uniqueness

The Venus chair (Yoshioka, 2008) reiterated the meaning of utilizing nature with the chair made through the crystallization process. Another example of the Yoshioka design group is a recycled bag by Freitag. Every bag by Freitag becomes unique as its materials, are applied incidentally in the process of using the fabric used in trucks. This makes consumers give special meaning to the bag, increasing motivation and ownership. It makes the brand image trendy (JOH & Company, 2011).

3. Self-morphing Randomness as a Design Method

3.1. Exploratory workshop for seeking diverse methods applying randomness to design

The design workshop was implemented to study the new method applying randomness to design. At the workshop, seven graduate students majoring in industrial design participated. At the beginning of the workshop, four examples of modern art that applied randomness (figure 1) were introduced to demonstrate the theme and trigger creative dialogue on randomness. Participants had 10-minute sessions on ideation for each picture, which was observed and recorded. An in-depth interview was done at the end of the ideation.

Figure 1 Artworks applying the notion of randomness used in the creative design workshop (from left, Variations by John Cage, Le Grand Verre by Duchamp, Number 28 by Jackson Pollock, and Wind Map by Viegas and Wattenberg).

Diverse ideas on methods of applying the randomness were classified. Considering the possibility of product production or industrialization, we mainly focused on methods that could be controlled by producers. We identified three main actors creating randomness: artifacts, nature, and people. The following are the suggested system models that connect between designer, producers, and consumers to apply the randomness to product design.

(1) Mass production by small companies utilizing mediating agents
This is a model where a designer utilizes a mediating agent for cost-effective production. This system allows mass production for designers without the infrastructure of large companies. Commercial services such as Alibaba global market (2014) and Global Sources (2014) work in a similar method already. These services connect designers to factories in China where low-cost production is possible.
(2) Achieving diversity through users' construction of an unassembled kit
This is a model that applies randomness utilizing human physical characters or the situational data of users. Such data is randomly converted and applied into a product kit. Initial kits would be the same, but the diversification is achieved through users' involvement.
(3) Application of the randomness utilizing 3D printing
This is the model utilizing 3D printing that has become recently popular. Using a software application with algorithms for random creation of forms, it is possible to create diverse products.

3.2. Self-morphing randomness: a method to create a unique design

Based on the literature review and the workshop results, we propose self-morphing randomness as a design method to create a unique design for each user. This technique fulfills the demands of users for differentiation and diversification in product design.

Self-morphing randomness is a design method in which unique style of a product can be made by utilizing fundamental characteristics or the nature of the product's function. Fundamental characteristics of a product refer to the major functions the product provides. In the case of a light product, providing light is the major function and the fundamental characteristic of the product. With the self-morphing randomness method, the fundamental characteristics of product function become the deciding factor in completing the product. Examples of products created using this method include a lamp made by initiation of light and a fan created by applying the data of the wind. For the product created using this method, the fundamental characteristics of its function becomes the parameter that completes the final form the form influences the product's function recursively. Utilizing the functional nature of a product refreshes the story of the product, and individual experience within the usage context is applied to the final stage of the product completion.

(1) Considerations of the method

To make it possible to apply randomness to product design, we considered the following issues and set up the requirements.

① Requirements for mass production

We decided that the product idea should allow designer to control the randomness in the product design life cycle. The product idea should allow repeated production and be appropriate for mass production.

② Requirements for supporting uniqueness for end users

The design should allow users to keep their own identity and use the product as means of expressing personality. The design needs to raise the scarcity value by allowing the user to experience the process of the product completion or historical meaning in addition to the diversity and uniqueness of the form.

③ Requirements to raise product symbolism

The design allows for the creation a story in the process of randomness application. For example, natural phenomena can be used as means to create a story behind the randomness.

(2) The Evolution of Design Cases

We explored many materials and techniques to seek new ideas and to verify the diverse possibilities of new products (figure 2). The materials we tested in the design process include epoxy resin, blue print, candle, cotton fabric, balloon, metal powder, prism, and others. These materials were tested in combination. As influencing factors of randomness, we considered light level, rotation of motor, changes as time, wind, magnetic, and so on. As a method of forming, we tested trapping, hardening, dropping, and shakings.

Figure 2 Experiments with different materials to seek design opportunities.

An example of interim design case in the trial phase is a randomness product concept utilizing the candle and the light. We used the fact that the light source changes depending on the direction of the sun. The brightness of the light is influenced by many illumination factors. Also the light can be a good element in the context because it is also location-dependent and affected by surrounding factors in a room. On the other hand, the candle is a material that creates the light or illuminates the light. We chose the candle as a design material in our design experiment because of its unique aesthetics and high potential as medium for an emotional product.

4. Design cases applying self-morphing randomness method

To explore how the self-morphing randomness method can be applied to the design process and how the product can be provided to end users and manufacturers as a system, we developed three product design cases: LmL (Light-morph-Light), LpL (Light-print-Light) and SmS (Sound-morph-Sound). The details of each design case are as follows.

4.1. Design case 1: Light-morph-Light

Light-morph-Light (LmL) is a light stand designed using the self-morphing randomness method. It uses the light, the fundamental nature of the product's function, as the main parameter to finalize the product. Through the final completion process, the product becomes unique. A user can purchase the product as a semi-DIY ("do-it-yourself") type kit. The user participates in the construction and the finalization of the product after purchasing, thus the product can be mass-produced differentiating from existing craft-type unique products.

(1) Design considerations and the evolution of LmL

We considered a number of issues in the design process. First, the scarcity can be achieved by the parts where the randomness is applied. Second, the product should include natural beauty created from the incidental generation process. Finally, we considered whether the product could be mass produced and was appropriate for an existing distribution chain.

(2) Prototype configuration

① Details of hardware and systems composition

LmL consists of a frame, candle, and rotation base powered by a solar cell (figure 3). In this product, the shade is uniquely created in the rotating base. To create the shade after purchasing, a user fires the candle and the wax melts down to shape the random form of the light's shade on the rotating base.

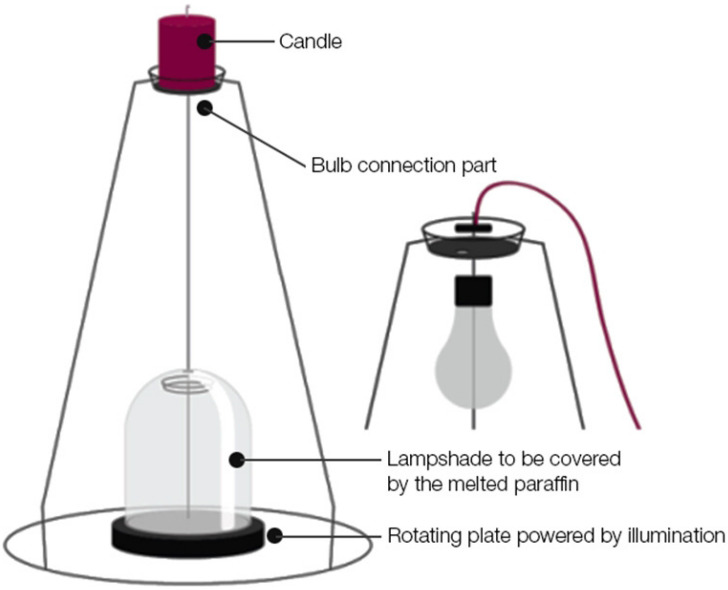

Figure 3 Concept sketch of LmL's structure.

LmL consists of a revolving base and a shade upon which melted wax is dropped. Combination of the size of the shade and material, turning speed of the vase, the candle, and its difference in height determines the unique style.

② Glass-type lampshade and candlestick

The lampshade was set up at the height of 10 cm to 15 cm depending on the scale of the lamp. The crevice of the inner and outer layer of the shade was set to be 1 cm. The width of the candlestick was 5 cm to meet the diameter of the upper shade. This was the feature to control randomness during the completion stage.

③ Turntable powered by solar power

One of the main components of LmL is the turntable that changes the rotating speed depending on the intensity of the light. It has a similar structure to the display. We determined the number of panels to allow rotation while the shade becomes heavy during the creating process.

④ The creation of candle using encaustic medium

A candle with stronger hardness made by encaustic medium mixed at the ratio 8:1 of wax to crystal was used as the main material. We figured out that there is a big difference in the falling speed of melted wax depending on the shape of the candle. If the candle is too long, the wax might be hardened on the candlestick before it falls onto the lampshade, so the height of the candle is limited to less than 10 cm after trials. It had to have a small bottleneck with a wide bottom to let the melted wax flow down easily.

(3) Product purchase and installation scenario

The purchase and the installation can be done in several steps. A user buys a non-assembled regular kit from a store. To construct the lampshade, the user first chooses the location and time where LmL will be used. The illumination parameters for that location during the first usage period decide the shape of the lampshade. This finishing stage can be considered as cultivation. Figure 4 illustrates the steps: (i) the user prepares regularly fitted LmL kit; (ii) put it in the space to be used; (iii) if the user burns the candle for the required time (e.g., for a few hours), the wax melts down to form the shape of the shade; (iv) when the user is satisfied with the result, then the user reassembles the parts. Figure 5 shows an example shape of the finished LmL lamp in this scenario.

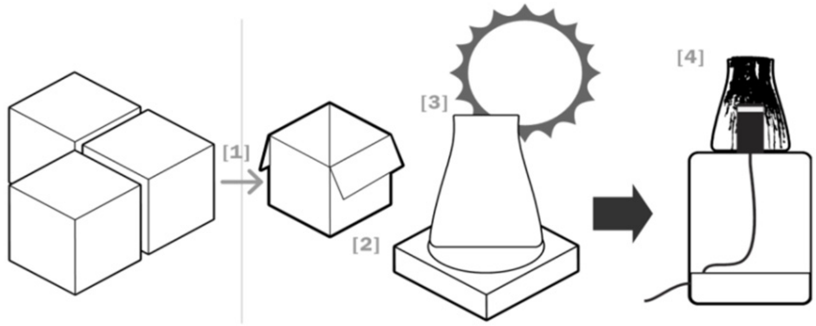

Figure 4 LmL's service system flow.

Figure 5 LmL concept design model.

4.2. Design case 2: Light–print–Light

The second design case, LpL(Light-print-Light), is the extended product of LmL. LpL is a lamp product in which data measuring illumination change in the initial usage stage decides the form of the main part (i.e., lampshade). The main part saved and transformed into 3D data is manufactured by a digital fabrication technique such as 3D printing. LpL shares the characteristics of using the light as the key forming parameter, but the method of applying randomness, shape attributes, material, production method, and the method of product distribution are different.

(1) Prototype composition

① Parts measuring lights and transmitting data

To measure the illumination, a PCB equipped with a microprocessor and light sensors (e.g., CdS cell) can be used. To measure the time, a tool such as a metro library can be used. The illumination data measured by the sensors are transferred to a server through a wireless connection, such as Wi-Fi or Bluetooth. This part can be embedded into the base, which is similar to the LmL base.

② 3D modeling

3D geometric modeling of the shade can be completed using input data of the light sensor applied to data formula of changes of illumination intensity by time. By using the linear formula, it can be set for the changes of illumination intensity reflected to the pattern directly. For example, data received at 1-minute intervals may be transformed into a circular graph. If the system accumulates six circular graphs in the vertical direction, a three-dimensional shape can be completed. Figure 6 is a rendered image of an example shape created using this method.

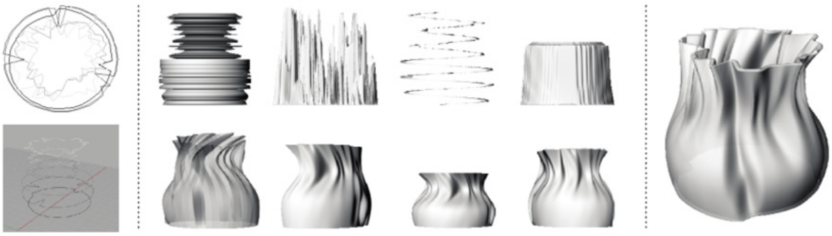

Figure 6 The process showing how the data is transferred to the 3D model of LpL's shade shape.

(2) Product purchase and installation scenario by a user

The purchasing and finalizing the form involves several steps. User installs a regular unfinished kit in the place to be used after the purchase. The way that the randomness is applied is the same as the process of LmL. But the difference is that it is processed by digital data formation instead of candle depending on the surrounding light changes. The product cultivation is done digitally. Next, the illumination data stored in the product is sent to manufacturing system. The completed product is made in the manufacturing system of the service provider. Figure 7 graphically shows this scenario. (i) When the user leaves the purchased lamp in the place to be used for one day, the lamp measures and records the illumination changes using the light sensor in the kit. (ii) The data is transmitted to the server system of the production company. (iii) The data is transformed into 3D geometric data of the lampshade and is 3D printed. (iv) The manufactured lampshade is delivered to the customer by post. Figure 8 shows an example of the final lampshade produced using this process.

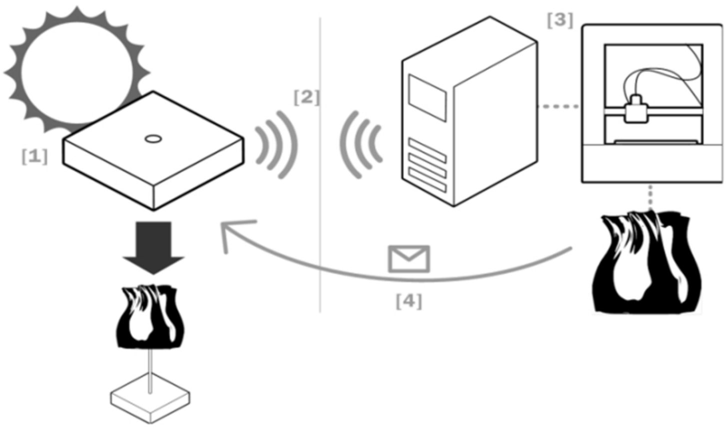

Figure 7 LpL's service system flow.

Figure 8 LpL's concept design model

4.3. Design case 3: Sound–print–Sound

Sound-print–Sound is a design case in which the self-morphing randomness method is applied to the speaker product. This case also uses the fundamental characteristics of the product's function, the sound, which becomes the key factor to form the final shape of the product. SpS is a kind of a horn speaker often used with a smart phone. Users do not need additional hardware electronic parts. The product can be used in connection with the application of the smart device. In the final form step for this product, the collection of the data and 3D printing is used as in LpL's case. For SpS, the changes of ambient sound, instead of the illumination changes, become the source of the modeling data that decides the incidental shape.

(1) Prototype composition

① Measuring sound data and transmission

One component of the system is an application to record ambient sound. A user may download the application to a smart phone and record the sound to transmit to the server system.

② 3D modeling

Transmitted data may be transformed into 3D geometric data by a formula of sound attribute by time that is similar to LpL. The shape can be reflected in the surface texture of the speaker.

(2) System use scenario

In terms of user experience of the purchase and the construction of the final form, SpS is similar to LpL. The user collects the data in the location where the product is to be used. The collected data is applied to the process of product cultivation. The ambient sound is the data for SpS's cultivation. The data is sent to a server system of the production company. The final product is delivered back to the user by post. Figure 9 shows the scenario graphically. (i) When the user leaves the smart phone after downloading the application of the ambient sound recording, the sound data is accumulated by time. (ii) The data is sent to the system of the production company. (iii) The 3D geometry modeling is done using a formula of data by time, and the final 3D model is 3D printed. (iv)This fabricated part is delivered to the user. Figure 10 shows an example shape produced using this method.

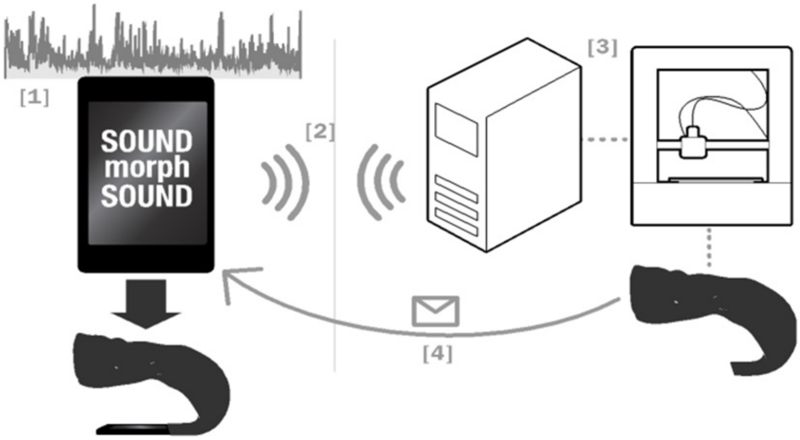

Figure 9 SpS's service system flow

Figure 10 SpS's concept design model

5. Evaluation of the product made by Self-morphing Randomness Method

5.1. Objectives and Procedure

To understand the impact of user experience and preference of self-morphing randomness products, we conducted a FGI (focus group interview) with potential users and design experts. The evaluation focused on seeing if the expected values are perceived by users through the design cases, and to examine if the users accept the products to a satisfactory level.

We used LmL as a representative design case because three cases developed have similar randomness features, and we expected it reveals the major issues. We recruited a product design expert who had more than 10 years of working experience. The questions regarded the feasibility and areas of improvements of the design case, reviewing the product photos, drawings, and explanation and scenarios. Issues of manufacturing and marketing feasibility were also discussed.

Seven (four male and three female) graduate-level students participated in the FGI. They commented on values and potentials of the self-morphing randomness method and the product case. The procedure had four steps. First, the participants filled out a pre-questionnaire. Second, they observed the product only with images to compare emotional value and the form with other lamp products. Third, they were introduced to the concept of the products and the design method. Finally, they answered questions about the values, challenges, and opportunities of the self-morphing randomness method.

The interview question included the questions on product comparison. We used an HA520 table lamp as a representative existing product for comparison. We used the questionnaire for the comparison, which was developed based on two key items of the industrial design quality evaluation criteria, emotional appeal and product differentiation, by Ulrich and Eppinger (1995). The questions were intended to understand general perception on the products by the participants instead of quantitative analysis.

5.2. Result

(1) Feasibility as a marketable product

The design expert commented that LmL is a feasible product concept and all the parts can be mass produced without any problems. To be a mass-production product, expansion of the product should be considered. Regarding the physical appearance, participants at the focus group said they appreciated the merits of LmL as peculiar and extraordinary. Uniqueness of the product could be connected to their interest, preference, and affection of the products.

(2) Areas for improvement

Areas for improvement and issues for further consideration were also identified from the interview and FGI. The participants mentioned that the form generated by the notion of randomness should appear promptly.

For improvements, it was suggested that the products can be created at a specific time or a location, so new meaning can be embedded. For example, LmL lamps made in Finland and Kenya will be different due to the light changes of a day. There were comments that the value of uniqueness should surpass the efforts made to construct, as seen from similar DIY-type products

There were suggestions that the time taken to build the product can be a means to increase value. We expect that if the ways to enrich this aspect and to embed the user's individual value in the product, the product can satisfy better user experience. If the product is cultivated on a certain day, such as birthday or anniversary, the user can recognize it to be the personally unique product holding the meaning of that time.

The results indicate that the process of product cultivation of the self-morphing randomness method can be a burden for end users, so special care should be given to reduce the efforts and uncomfortable tasks. Engaging user scenarios need to be developed to blend into the everyday environment. Consideration should also be given to the situation when the random form is not up to expectiation by users. LmL's glass shade can be reused by cleaning the wax with hot water. It would be recommended to provide a few solutions like this.

Wasting the materials was pointed out as drawback. To improve this, some parts can be made for multiple uses. For example, LmL uses the solar cell module. This part is used when the shade is first created. The cell part can also be used as a battery for the lamp at night.

Based on the feedback on value, challenges, and opportunities, factors to be considered regarding the self-morphing randomness method can be summarized as follows.

- Usability aspect: Allow the user to be comfortable in the creation process. Provide a few options for modification if necessary.

- Aspect of production: Consider the parts used for the process of cultivation (when the self-morphing randomness generates the form or the data of the shape) may be used for other functions in the product-use phase.
- Aspect of meaningfulness: The cultivation process needs to naturally take place in the user's everyday environment. Consider ways to add unique stories for the cultivation process.

5.3. Discussion: Value of self-morphing randomness product

From the literature review, the development of design cases, and the evaluation with interviews and FGIs, it can be said that the self-morphing randomness products can offer the following values.

(1) Storytelling

The method plays a role in creating personal stories during the product purchase and installation. The participants in the evaluation session appreciated the notion of the recursion, in which the light creates the lighting product. One participant commented, "If the product is made of the light on a special day, the story of the product is created." Another participant mentioned that such stories increase product attachment.

(2) Uniqueness

As expected, the method enhances the value of uniqueness of the product. Two aspects were mentioned as means of achieving uniqueness. The first was related to the fact that users experience the construction. As the users can see the process of cultivation, they perceive that the form was naturally cultivated. This experience strengthens the user's notion of owning a unique product, which also increases the level of ownership and the attachment. The second aspect involves the participation and effort made. As Tian et al. (2001) pointed out, if a user puts more effort into the completion, the attachment and the feeling of uniqueness increases. The value of uniqueness would increase if the user uses the time of product cultivation in a more personally meaningful way. The example scenario was to build the product on one's birthday. The owner would think the product has the same birthday.

(3) Spontaneity

The method applies spontaneity in the final product completion stage. In graphic or product design, spontaneity involves natural aesthetics. With the self-morphing method, the product form expresses the spontaneity and unique characteristics similar to the objects found in nature. This can be the attribute to increase users' preferences. One participant mentioned that this resemblance to the natural object is unique and special to him.

(4) Emotional experience

The method increases emotional value, such as feeling freshness and coolness. The participants mentioned the final form of the design case reminds them of people who are artistic, unusual, and individualistic. They also commented that the use of the self-morphing randomness product can express the user's identity. The serendipitous experience is experienced also. It allows the user to consider the product as self-extension. The unique identity of the product differentiates it from ordinary mass produced products. The method helps to connect the user and the designer. It also offers the user to explore new creative potential.

6. Conclusion

This paper presented a design method and example cases to create unique products to meet people's needs for differentiation and personal identity. The method can become an alternative to mass production, as new digital fabrication technologies are widely available. The contribution of the work can be explained threefold. First, this work expands the application domain of randomness to product design from graphics and media art. We proposed the self-morphing randomness as a specific product design method. This method applies fundamental characteristics of a product as a means of creating randomness. We presented ways to realize the method by employing a semi-DIY method, 3D printing, and network data communication.

The second contribution involves designing three cases. The first case, LmL, is a lamp that uses the light of the candle to form the shape of the shade. Users experience the final realization of the main component of the product. The experience offers the value of uniqueness, aesthetics, and spontaneity to users. The second case, LpL, is also a lamp, but the lampshade is created from the data collected during the first usage situation. The data is collected from a light sensor and transformed into 3D geometric form. 3D printing is done remotely and delivered to the user by post. SpS is a horn speaker for a smart phone which uses a similar system and service to LpL. The design cases imply the potential that the method can be generally applied to many other products.

Lastly, we examined the value, challenges, and opportunities of the proposed method through expert interviews and FGIs. We identified the four key values of applying randomness to product design: storytelling, uniqueness, spontaneity, and emotional experience.

As future work, more analytic evaluation of the feasibility and applicability of the self-morphing randomness method to commercial products is required. User and market studies are needed to choose initial appropriate product categories. 3D printing technology is promising for this method, but a more concrete and customized system should be sought. Finally, more user study is needed to understand people's experiences, such as perceived value, attachment, or preference, over a longer period, when using the products designed using this method.

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