

User Involvement in Design: A Case Study of using an AM-enabled Mass Customisation and Personalisation (MC&P) Toolkit

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ABSTRACT

In the era of Mass Customisation and Personalisation (MC&P), users are incorporated in the design of their own products more explicitly with the aid of toolkits. There are nearly 1000 toolkits for MC&P already available to be accessed by Internet users. However, only a few of them are specifically AM-enabled, such as CellCycle and MakieMaker. This article focuses on a case study that employs user observation and questionnaire methods to highlight the benefits of MC&P. It is based on a toolkit designed by Loughborough Design School for customisation and personalisation of a lampshade, the manufacture of which was facilitated by Additive Manufacturing (AM) technologies. The case study suggests that the reflections of the participant's experience with MC&P, his quality of interaction with the toolkit and the value of the MC&P product produced through AM have practical implication for users, designers and software developers to improve user experience of MC&P and to enhance the value of consumer product designs.

KEYWORDS: MC&P toolkit, User involvement, 3D printing, User experience, Product value

1. INTRODUCTION

The design of an object is sometimes not only done by a designer, but also by consumers. The consumers take on roles in different steps of new product development [1]. Lynch and Horton [2] confirm this by saying that:

“If you listen only to management directives, keep the process sealed tightly within development team, and dictate to supposed users what the team imagines is best for them, be prepared for failure” [2].

The authors of this paper not only mean user involvement through a focus group or survey to acquire user's needs implicitly, but also giving users the autonomy to customise and personalise; to design the products themselves in a more explicit way, which is a part of MC&P. The use of consumer involvement reveals the configuration of processes and technologies that must be used to manufacture mass customised and personalised products [3].

In order to obtain their needs-related information, consumers are usually required to attend some activities, the cost of which, (in both monetary and non-monetary terms) is not small [4]. To enable a deeper level of consumers' involvement a user toolkit can be used, with an interface that provides them with a design solution space. In this method, the needs-related information is acquired based on the solution that is provided through the involvement of the consumers. It does not cost as much as conventional methods [5], and it is faster. MC&P toolkits have been defined as “a set of user-friendly design tools that allow trial-and-error experimentation

processes and deliver immediate simulated feedback on the outcome of design ideas” [5]. There are two important enablers of mass customisation and personalisation; one is advancements in information technology, and the other is improvements in manufacturing techniques.

To end users, the purpose of MC&P is to meet their economic, psychological, and social needs by creating an exclusive and distinctive product. Through MC&P, users are not only pursuing a product’s function and aesthetic feeling, but most importantly, they are conveying their self-image, personality, and taste [6]. Merle et al. [7] have proposed the concept of the perceived value of an MC&P product by breaking it down into two components, product value and experiential value. The first value is related to the anticipated consumption experience and the second value is linked with the interaction between the consumer and product during the co-design stage [8]. Hence, it is assumed that users will attribute a higher value when they enjoy the interaction and effort they have put in during the process of self-designing a product [9].

1.1 AM as an enabler of user involvement in design

As the users become more involved in the process of creating their own products, and are given the ability to change the product considerably in some cases, AM has become an enabler to deliver this service. AM can be defined as “a process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies” [10]. This allows the outcome of a toolkit, either the product or part of the product, to be manufactured by AM. The toolkit, therefore, becomes a tool for novice users to create/modify their product easily. Due to high surface manipulation and variation in MC&P toolkits, the output has to be manufactured by new manufacturing methods in most cases, such as AM. Therefore, the MC&P toolkit additionally becomes a design interface or software for novice consumers to produce their products with personal 3D printers.

In recent years, some MC&P toolkits have become AM-enabled. This means that the result of the MC&P toolkit, ordered by the consumers can be readily manufactured by AM. As explained before, with AM-enabled MC&P, there are fewer boundaries for complexity of the shape of the product to be manufactured. Therefore, the consumers can “play” with the shape of the product, and create very radical and complex patterns and shapes. Previous research points out that a collaborative consumer design is required, where part of the product design is done by the designer and the remainder by the consumer [11] to allow consumer directly involved in the process of designing a product. A design approach such as Consumer Design Products offers a possible way for end users to be actively involved in designing their own products so that they can exercise control over the product in which require them to operate as co-designers of their own personalised designs [12]. However, this would create some problems for designers if they want to protect the brand’s image and product design language. Therefore, MC&P toolkits have to be limited in terms of options, features, and boundaries in order to be acceptable to designers, and consequently companies [13].

2. CASE STUDY MATERIAL

This importance of visualisation and realistic representation of the product in 3D in AM-enabled MC&P toolkits consumers has been increasingly paid attention. At the early stages of this case study, there were only a few toolkits that were employing THREE.JS in order to represent their product in 3D on websites (e.g. CellCycle from Nervous System) [14]. By the later stages of the case study, more toolkits were added to this list (e.g. Shapeshifter.io (Autodesk) and Platypus

(CORE studio)). This can be achieved either by using 3D-enabled programming or by making current CAD systems web-based.

The main source of material for this study was the MC&P toolkit that was created and adapted based on a previous study and workshop [15] in THREE.JS. In this toolkit, a user can start by choosing a “product type” (Fig. 1-a). After choosing the product type, he/she can select a parameter, such as radius, edges, and sides, and manipulate the product’s surface with the aid of control points (Fig. 1-b). Next, the user can try to put a pattern on top of his/her design, such as hive, star, bevel, etc. (Fig. 1-c). Next, he/she can add a colour or transparency to his/her lampshade design (Fig. 1-d). Finally, in the physics section, assess if his/her design is going to be installed properly after manufacturing (Fig. 1-e). At the same time, the user has access to price, dimension, and shadow visualisation (Fig. 1-f), which virtually shows the shadow effect of the lampshade on the walls (Fig. 1-g). The user also has the chance to undo, reset camera view and save his/her design at any stage of the process (Fig. 1-h).



Figure 1: Different features/stages of the Lampshade Toolkit for MC&P

3. DATA ACQUISITION

There are three main types of evaluation and data acquisition for user interfaces as follows [16]:

1. Review by Human-Computer interaction expert (or heuristic evaluation).
2. User testing (with observation of users).
3. Survey of user attitudes and perception.

There is a need to focus on understanding deeply who the users are, and how the users perform their tasks when designing a user interface, hence options 2 and 3 are preferred. Users are mostly unable to fully articulate what they really do with user interfaces, even if they are very familiar with the tasks they perform. Therefore, a more appropriate way to analyse the user's behaviour, and consequently the interface, is to observe the user while they are using the interface. Since the aim of this study was to explore user interaction with a toolkit and extract useful data for creating a design framework, a combination of observation and questionnaire was chosen for data acquisition

Observing users in their “natural setting” is an essential part of user-centred design. In addition to finding out what users do, the aspects of the system that they like or dislike, can also be discovered. The observation can be either direct or indirect [17]. In direct observation, the users may be interrupted by the observer, as they are in direct interaction, and it can happen either at a natural workspace or in a laboratory environment. In indirect observation, the users are monitored without any interruptions, and the observer is usually not present at the location. In this work, the observer needed to interact with the users and vice versa, and so direct observation was selected.

Observing, listening, and talking to users in their own workspace (through site visits or field-testing) is considered as the best and more realistic route to designing useful products [17]. An easier method than site visits is to bring the user to the researcher's work place, provide them with a representative workspace, and then ask them to perform the tasks. The latter was chosen in this study because the former was less feasible, since participants needed to be observed while doing the customization. In terms of creating a representative environment, the users were placed in a quiet, comfortable setting and refreshments were available in an attempt to simulate their home environment.

In the “thinking aloud” method, the user is encouraged to say what they are thinking while executing their tasks. The user is prompted with questions such as what are you doing now, what are you looking for, how do we do that, what will happen if you choose that option or why has the system done that? It is important to ask users to explain themselves in their own words, and let the observer know if they are confused about anything. This makes sure that any hard-to-understand problems are identified and explained in the user's own words.

4. METHOD

Ten participants were sent an email containing the participant's information sheet, and were requested to participate in the study. They were also informed of the incentives, which compensated their time and effort for their participation. There was also a prize draw to motivate the users to take the customization seriously. The winner would receive a 3D-printed version of the lampshade that he/she had designed with the toolkit. Following their agreement, a

time was agreed for the session. There was no actual need for them to bring anything to the session but they were encouraged to bring anything that they wanted to show or discuss in relation to the study, e.g. a product they had previously personalised. Each participant was required to sign a consent form at the beginning of the session. After signing the consent form, they were asked to sit comfortably as if they were customising a product at home, and in such a way that their actions could be clearly video recorded.

In their first task, the users were provided with three interfaces with different levels of capability and complexity. They were asked to use those three interfaces and choose their preferred one. They were also asked to think aloud during interaction in terms of what they were trying to do, and why, and what responses they expected to receive from the toolkit, and why. They were also asked to express their thoughts about the responses they did actually receive.

The next task continued using the interface they had chosen in the first task. In this task, they were required to customise a lampshade as if they were going to buy it. They were already informed about the prize draw, encouraging them to take the tasks seriously. Again, they were requested to think aloud during their interaction. Finally, after using the toolkit, they are given a questionnaire about usability to complete.

Whenever they found themselves in a situation, where they were unsure about what to do or what effects commands might have, they were allowed to ask the researcher for advice. If they asked the researcher, what they needed to do, he firstly suggested things for them to try, but if they were completely stuck, he explained exactly what to do.

After all the participants had completed their designs, one participant's name was drawn out and he was given his 3D-printed lampshade. Figure 2 shows the winner with his 3D-printed design. He was then asked to complete a second questionnaire regarding the value he placed on the customisation experience and the final product that he received.



Figure 2: Winner of the prize draw with his 3D-printed personalised lampshade

5. FINDINGS

There were three types of findings based on the questions that the winning participant answered; his experience with the MC&P process, the quality of his interaction with the

toolkit, and his reflection on the value of the personalised product. Regarding the experience with customisation & personalisation, the participant confirmed that he had had a good customisation experience. The reason for that can be inferred from his comments about the uniqueness of the design, the product's contribution to self-representation, and his desire to use the system again in the future. His reflection on the interaction with the toolkit was promising, indicated by comments such as: the system was easy to use, easy to navigate, new and exciting, well-integrated functions, being easy to learn for most people, enough variety to choose from, enough tools such as undo and view reset, and useful feedbacks, such as price and dimensions.

About the issues on interaction with the system, he added that more options are needed for product types, not only cone and polygons, and more help and explanation are required on how the physics of the product works. The other nine participants in the first stage of the study, who have not yet been taken to the second stage of the study, also commented on their MC&P experience and the quality of their interaction. Their comments on their customisation experience and the positive aspects of the toolkit confirmed the same result mentioned previously. However, their comments on issues with the system also included "lack of guidance on control points", "more explanation on titles and design tools", "inaccurate title selection for modifiers and shadow visualisation", "a lack of pop-out information", "more colour choices and customisation options" and "control points too small".

In the second stage of the study, regarding the winner's reflection on the design attributes of the 3D-printed product, he stated that he was looking for an attractive, pleasant and delightful shape of lampshade by trying to have features that reflected his personality and a design that was distinct from others. To make the lampshade more distinct from the standard designs, the participant tried to adapt patterns on the surface of the lampshade to make the projected light more attractive and effective.

In terms of co-design activity, he stated that he wanted to alter the shapes, sizes and form of the lampshade to best suit his needs. The participant has put his effort into finishing the design by repeatedly changing the component parameters to improve the design appearance, according to his desires. His goal of personalising the lampshade was more about appearance, which he wanted to adapt in line with his personal taste and style.

Regarding the experiential aspect of his interaction during the MC&P process, he found that the process of designing the lampshade using the toolkit was enjoyable, fun and able to fulfil his imagination. During the process, he was eager to explore more design possibilities, felt excited about finishing the task and had a sense of accomplishment when he finished the design. He also found that the MC&P process was a great "play" activity and a delightful thing to do. He strongly agreed that having a personalised 3D-printed lampshade enables him to stand out in comparison to other people who only have a standard lampshade design. He also acknowledged that by personalising the lampshade, he was directly making a contribution towards the design of the lampshade. He also strongly agreed that by making use of 3D printing, the MC&P process enabled him to specify design features that were best suited to him.

During the study, the initial price for the lampshade was shown in the MC&P toolkit and was estimated at £308. Eventually, the actual price of the 3D-printed lampshade was much lower at £111. However, the participant's expectation for the price of the 3D-printed lampshade was extremely low compared to the actual price, indicating that he would only be willing to pay a much lower price for the 3D-printed MC&P product. This highlights the fact that either

companies considering the use of AM-enabled MC&P should target consumer segments with a higher willingness/ability to pay more for 3D-printed products, or they must find ways to reduce the manufacturing cost of 3D-printed products.

6. CONCLUSION

The case study of the lampshade toolkit illustrated how effective user involvement can be in the design of a product specifically in the MC&P era. It is a tool that allows users to experience MC&P activity by directly manipulating design parameters. This interaction leads to a more appreciated personalised product in terms of the experience and product value.

Through this case study, it can be concluded that the MC&P lampshade toolkit had features and a layout that were relatively easy for users to understand, e.g. physics providence, direct manipulation, and 3D real-time visualization. However, there is a risk that the user may not understand all the options well, and he/she would need more guidance on some topics. The evidence from this case study also suggested that the MC&P products that are fabricated using AM technologies could enhance value to the user. This is achieved through the active participation of users to facilitate a positive co-design experience as well as creating a unique and self-expressive design that can embody personal taste and style.

The researchers hope that the lessons learnt through use of the lampshade toolkit, will pave the way for designers and software developers alike to explore new concepts and interaction methods in order to build toolkits that are more effective in the future. MC&P is a favourable strategy for users to differentiate their products from those seen in mass-produced markets in order to satisfy their individual, unique needs. In addition, users can enrich their personal experience through involvement in the MC&P process, particularly when it is facilitated by the flexibility and speed of AM technologies.

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