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EXPLORING A USER-FRIENDLY MASS CUSTOMISATION TOOLKIT WITH HIGH DEGREE OF FREEDOM

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Abstract: *The capacity of Mass Customization (MC) Toolkits to empower customer choice through the provision of utilitarian and aesthetical options has received increasing attention by researchers and practitioners [1]. Therefore, design of this capacity is of high importance due to its influence on the user's perceived value. There is a trade-off between High Degree of Freedom (DoF) and User-Friendliness regarding the design of the capacity. Therefore, the existence of this combination in a Mass Customization Toolkit (MCT) is desirable. To investigate that, an MCT with enhanced solution space (high degree of freedom and user-friendliness) was developed. In this article, the characteristics of the developed MCT is explained. A user trial was performed with numbers of staff members from University of Cluj-Napoca and Chinese Students in a summer school at Loughborough University to obtain user insights, elucidated in the findings section. At the end, the pros and cons of the MCT were discussed and conclusions and future works were also presented.*

Key Words: ***Mass Customization, Mass Customization Toolkits, Degree of Freedom, Guidelines***

1. INTRODUCTION

Mass Customization has two contradictory terms: "Mass" which is a reminder of Mass Production and indicates provision of products in large quantity and low prices, as much as it is in harmony with the next term: "Customization" which indicates manipulation and changes that can be made to the product in order to be fit to the customer's needs and desires. This new shift tries to combine high quality and tailoring of craft production, and efficient price and production time of mass production. Mass Customization aims to meet each customers' requirements [2]. In order to obtain user requirements, companies allow customers configure their products either offline (in store) or online (by toolkits) [3]. The online touch-point, in which available choices for products are given to the customers to select from by the company, called Mass Customization Toolkits (MCT). MCTs 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 [4]. An effective MCT should elicit satisfying consumer experience [2].

According to Pine's definition of MC [5], nearly everyone's desire should be met by having enough variety and customization. Having high flexibility (close to the experience in CAD software programs), which fulfils customers' desires more truly (close to Pine's definition of MC) [5], both higher-level attributes such as shape and material, and lower-level attributes such as color and surface prints [6] should be available to customers to choose from. In other words, customer experience would be improved when they are confronted with high Degree of Freedom. Degree of freedom is defined by the number and variety of available options on the toolkit [6]. There are more than 1000 of MCT available on the net [7]. However, few of them enable customers to manipulate higher-level attributes of the product, the examples are Cell Cycle [8] and Sketch Chair [9]. In fact, very few of them provide the number of higher-level attributes. In the meantime, high degree of freedom should be managed to be displayed in a "user-friendly" manner. Otherwise, even though the toolkit provides high degree of freedom which is required, the toolkit may cause "Mass Confusion". The state which customers are overwhelmed with number of options available on the toolkit, is called "Mass Confusion" [10]. The high number of options which in essense help customers to have the product they desire, in other sense, it may cause difficulties to choose the right product (product variety paradox)[11]. The more degree of freedom the toolkit has, it is likely that the MC toolkit is proner to "mass Confusion" or "product variety paradox", therefore, the more attention should be paid to the user-friendliness of the toolkit [11]. Considering higher and lower-level attributes, a user-friendly MCT for customization of rings was developed. Several researches have been dealt with the design of MCT to enhance the utiliterian benefit of the configured products and the effect of different features on consumer-percieved benefits [12,13,14,15]. This research has mainly focused on how MCT should be designed to enhance the user experince. Therefore, numbers of recommendation for implmentation of MCT are proposed which affect the consumer-percieved benefits as well.

2. DEVELOPMENT OF THE MCT

In order to offer both aesthetical and functional options, ring was selected. Furthermore, the price of production (considering modern manufacturing methods (Additive Manufacturing)) due to its small size is comparably lower for rings. The MCT was built with three.js [16]. Three.js is a 3D-enabling library which eases the use of WebGL to present 3D objects on the web. Three.js allows providing of 3D visualization of products on the toolkit as one of the most important features [17]. Using three.js, it also enables the toolkit to be web-based for customers to access it through the internet.

The MCT has been developed with new reconsiderations of the way of programming (using object-oriented programming). Basic options such as height, radius, etc. and advanced ones such as twist, taper, etc. were implemented which could be manipulated with the aid of buttons (indirect manipulation).

Using buffer-geometry – which is for storing vertex positions, face indices, normals, colors, UVs, and custom attributes within buffers; this reduces the cost of passing all this data to the GPU – enabled quicker responses to manipulations. This means that the visualization feedback is updated rapidly once a slide is dragged. However, using a big mesh for the product to have smooth edges makes the response time a bit longer than usual in some cases.

The user interface was also divided into three main parts with HTML, and CSS. The left bar includes the logo, the save and reset buttons, ring's cross section, main geometrical options (height and radius (both globally and locally)), color selection, and dimensions of the ring. The central bar contains the visualization feedback of the ring, and patterns. The right bar contains the specific geometrical options regarding the ring (basic and advanced options) such as taper, twist, etc.

After selecting the ring type, and change the primary geometrical characteristics of it on the left-hand side, the user can select and vary more auxiliary options from the right-hand side. The toolkit is presented in Figure 1.

3. USER TRIAL AND TESTING METHOD

The user trial was conducted with 10 participants, who were staff members from the university of Cluj-Napoca and Chinese Students in the summer school at Loughborough University. The user trial was held in Loughborough Design School. The users were computer literate, and had design backgrounds. They had varied level of familiarity with CAD from none to high. They were shown the user interface, and asked to use it to create numbers of different rings (Figure 2).

The task was to create ring designs of their own, assuming that they were going to own the ring at the end. The method of data collection were voice-recording while they were using the interface. A controlled laboratory setting was chosen for this study rather than a home setting to remove any potential environmental bias.

The toolkit was created based on three criteria: the toolkit is web-based, allowing online customization of the product, the toolkit focuses on consumer product, and lastly the toolkit allows online ordering of the final product. These criteria have been chosen to be align with most of available toolkits in the market.

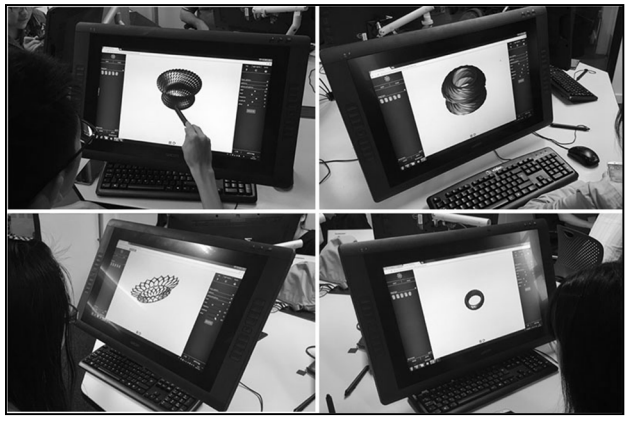

Fig. 2. *Examples of ring designs, from the user trials*

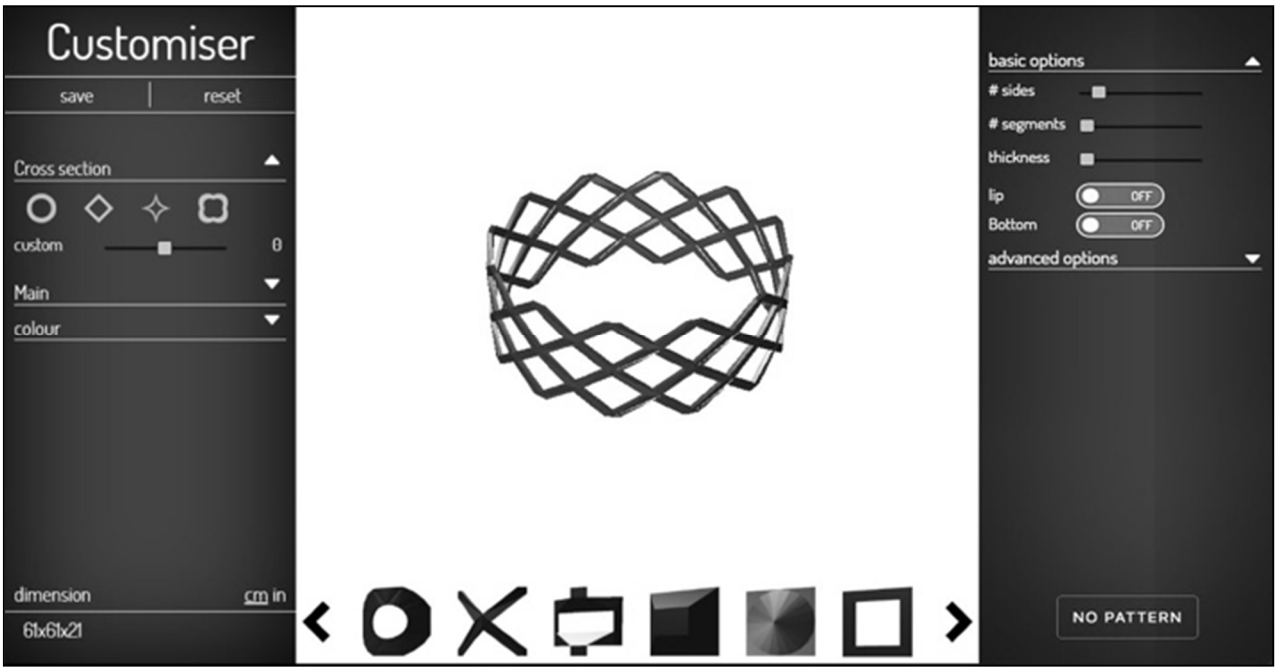

Fig. 1. *The MCT for rings (considering high degree of freedom and user-friendliness)*

4. FINDINGS

The participants were impressed with the freedom they had regarding the shape and patterns of the ring, and the variety of the rings they can create. Furthermore, because of the "save" button they were encouraged to explore the options to create something they know they would be able to manufacture with 3D printers. One drawback, though, was that the toolkit only worked properly in chrome, and not in Internet Explorer.

Two of the participants commented that the position of frequently-used-buttons such as undo button should be somewhere close to the product visualization, not only to make it easy to be recognized in the first place, but also to ease frequent use of it.

Users were looking for basic guidance on using different elements, which require quick and simple guidance facilitated by hovering the cursor over them. A separate page for help was used in order to explain items in more detail but was not necessarily desirable. In terms of guidance, pop out/hovering help windows are more desirable. One participant's comment demonstrates this well:

> *'the problem with help in separate screen is that you feel you have got to remember it for where you get back to the interface, I wonder whether the help could be like a drop down list as well, where you just select the topic and the small windows appears with the information about that specific topic.'*

Furthermore, the visualization of some patterns was not clear enough for users to be recognized. The patterns were arguably not depicted clearly and were complicated to be understood.

In terms of DoF, three participants wanted more options for the toolkit. Three participants mentioned that the current number of options was enough in the high DoF UI, but some other tools are required in order to make changes easier for the customers such as menu options. Three participants mentioned that the current number of options in the high DoF UI was too many, and some tools were specifically required to ease the process for manipulation. The lack of tools such as mirroring, keeping symmetry and parallel modifications were mentioned by participants, which are common in 3D CAD systems. Finally, most of the participants complained about the lack of color choices in the system, which was limited entirely because of time limitation on developing the MC toolkit.

5. DISCUSSION

Some important insights are discussed further as below:

Allowing customization of the toolkit: The user insights regarding the freedom during customization demonstrates the paradoxical nature of degree of freedom throughout the results. A comment by one participant sheds some light on this matter:

> '*So going back to my earlier comment about having too much control on the parameters, I am begin (sic) to change my mind now, and I think it is helpful to have that level of control. It is just a matter of practice playing around with different ideas and obviously it gives you a lot more flexibility to be creative... yeah, and once you see the possibilities to have extra options, people will naturally prefer to have them, because it just gives you much more control to create shapes that people like.'*

This participant firstly commented that there were too many parameters, which intimidated the user from using the options. However, after he grew more experienced in using the system and became familiar with the options, he changed his mind. What could be inferred is that users do not actually like low number of options, and even if high degree of freedom is undesirable in the first place, they get used to it later, confirming that an MCT with High Degree of Freedom is what a software programmer should look for.

First on screen and direct help, second indirect and descriptive help: One important suggestion for AM-enabled MC toolkits is the need for easy to use and interactive guidance. On screen and instant help, either over the items by hovering, or on the side of the screen by clicking on the items seems essential, in the first instance. Using pop-out and also hovering windows to inform users of the titles, and their work flow makes the interface a lot more understandable, and at the same time only requires a short amount of design time in comparison to creating the customization options. Furthermore, an introductory video proved to be effective in terms of introducing the participants to the concept of customization, and how the system worked. This straightforward help for using the system can be very effective in teaching the users the most important features of the toolkit, and in guiding them through the process.

General Guidelines: If an interface has enough free space, then implementation of a bigger area for different feedbacks is a requirement. A better visualization or simulation showing the virtual wearing of the ring would likely be more useful. The perceived issue of a lack of expected design tools shows that more tools, which would make the current options easier to manipulate, and products with more variety to be generated, is desired.

6. CONCLUSIONS AND FUTURE WORKS

The MCT has numbers of advances; variety of patterns including English alphabets, variety of geometrical options from radius and height to twist and taper (basic to advance), quick response time with each manipulation, user-friendly interface (graphically engaging), sorted options for quick referring, and flexibly navigable (options are saved while other options are being explored).

The disadvantages of the MCT includes; only aesthetical options were provided and the only functional aspect was the size of the ring, lack of reference object (having a finger, etc. with the ring as a reference of the size, etc.), not all the options are manipulatable directly on the product, and limited in term of local manipulations (for example local manipulation of height is lacking).

The MCT had a good feedback from the user trial but it still has many aspects to be improved. Ring was a good choice for being cost effective, and circular object (easy to be programmed). Considering the complexity that additive manufacturing can handle, the DoF of the toolkit

can still be increased, but in categorized and sorted way to satisfy the customers and not confuse them [11]. The graphics of the user interface can be improved with more advanced use of CSS; this includes transformation, transitions, etc. Save button for saving STL file of the object was useful as users tried to use it, which encouraged them to explore more possibilities. Three.js along with HTML and CSS were good choices for creating these user interfaces as three.js enables 3D visualization on the screen and HTML and CSS enable other important features of MCTs, such as side by side comparison, etc.

Since there was not a reference MCT in order to understand the significance of the MCT developed and also comparison of them, then those must be mentioned as limitations of the study.

Future work will be conducted mainly on creating a more detailed framework, which will provide step by step guidance on almost every essential feature needed in a toolkit. In terms of User-Friendliness, further research and development are necessary to create and examine toolkits for different products one by one. This will lead to improved guidelines for a variety of products. Furthermore, a set of basic evaluation surveys specifically for these types of toolkits is also lacking. The area of degree of freedom also needs to be extensively investigated for a variety of products to make sure each toolkit has an appropriate number of options.

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