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Design Guidelines for Implementation of User-Friendly Mass Customization Toolkits

Hesamoddin Yavari[1*], Ahmad Nedaei Fard[2], Ian R. Campbell[3], Matt Sinclair[4]

[1] Postdoctoral Researcher, Department of Industrial Design, Faculty of Art, Alzahra University, Tehran, Iran.
[2] Associate Professor, Department of Industrial Design, Faculty of Art, Alzahra University, Tehran, Iran.
[3] Professor, Design School, Loughborough University, Loughborough, UK.
[4] Instructor, Design School, Loughborough University, Loughborough, UK.

[*] **Corresponding author:** Hesamoddin Yavari[1], h.yavari@alzahra.ac.ir

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Abstract

Mass Customization (MC) Toolkits are basically user interfaces that facilitate communication between the company and customer for customization of products, which transfers design data to customers and user data to companies. These toolkits have some characteristics such as 3D visualization, price feedback, material selection and design tools that make them different from common websites. Therefore, current guidelines for common user interfaces should be improved specifically for mass customization toolkits. This paper aims to propose design guidelines from users' point of view for web-based MC toolkits that enable software developers and designers to have some fundamentals in hand and to follow them. First the elements of mass customization toolkits, which had been obtained by literature review were presented. Next, result of a study was illuminated to demonstrate the ranking of the elements and their preferred on-screen position. Finally, guidelines were provided for designers and software developers, followed by conclusions and future works.

Keywords

Mass Customization Toolkit, Design Guideline, User Experience, User Interface Design.

Introduction

Many companies, when confronted by the new era of manufacturing — i.e., MC— recognize the need to stay competitive and to adopt new methods and strategies. However, the fast-changing nature of competition requires companies to react quickly with new approaches. One of the ways that companies respond to MC and try to incorporate it, is by providing MC toolkits for customers (Trentin et al., 2014).

Each MC toolkit has its own characteristics (Abbasi et al., 2013). By reading articles about MC toolkits, CAD software programs and MC sale websites, it is possible to find out many characteristics that have been created, used or have been suitable for MC toolkits. They have been applied to the MC toolkits to some extent. In this paper, instead of characteristics or specifications, the term *feature* is used to indicate small chunk of each toolkit. As a part of the analysis of these toolkits — and solution space design process— the features that need to be chosen for an MC toolkit must be identified. Having all of them in an MC toolkit may not be feasible due to either mass confusion or 3D CAD software limitations/incapability. Furthermore, this process of identification should be done by the MC toolkits' users. According to Zhao et al. (2018) as well as Franke and Piller (2003), these interfaces should be analyzed and developed from users' points of view in order to be efficient and effective. Therefore, all of the features were ranked in order of importance, also their on-screen positions were obtained by the participants.

This paper is structured as follows; in the Literature Review section, definitions are given for the terms used in the area of MC toolkits and previous research regarding their anatomy are discussed. Afterwards, the Research Method is presented in order to explain the actions undertaken during the complete research process. In the finding section, Card Sorting and Wireframing are explained followed by the study findings and discussion. The paper ends with conclusions, pointing out the important implications for industrial designers and other professionals such as software developers, who are engaged with developing MC toolkits.

Background

The solution space takes shape with the aid of typical elements shared among different MC toolkits namely, Navigation, Feedback and Guidance (US Department of Health and Human Services, 2006). Each key element of an MC toolkit can be divided into smaller features; e.g., visual feedback, price feedback, side by side comparison, technical information, etc.

Toolkit Features

Having explored related materials, Computer Aided Design (CAD) software programs as well as MC sale websites, all the possible features for MC toolkits were collected to be assessed within the study (Table 1).

Table 1: *The possible features for MC toolkits along with their definitions.*

Features	Brief definition
Visual feedback (Hermans, 2011)	A feedback regarding visualization of the product's 3D model once a modification was made to the model
Virtual use of product (Saul et al., 2011)	Using the object virtually during or after customization in order to find any faults or see how it works
Guidance (Randall et al., 2005)	Help in using the system
Technical information (Dell, 2014)	Providing information based on products' specifications to ease the process of decision making for customers
Validation with feedback (Hermans, 2011)	Providing information regarding compatibility check and/or any physical/technical faults
Physics providence (Igarashi, 2010)	Providing information about products' choices based on physics law

Reference object (Hermans, 2011; Hermans, 2012)	An object to be accompanied with the customizable product as a reference in order for comparison or color/size matching
Starting point (template or blank canvas)(Hermans, 2011)	The place or point where customers start their design from
Direct Manipulation (Stone et al., 2005)	The extent of which the interface or customization process is interactive
Price feedback (Hermans, 2011)	A feedback regarding price, once a modification happens to the product's variable attributes
Need-based or parameter-based (Randall et al., 2005)	The way the variable attributes are exposed to the customer either based on relative importance of their needs or based on the product's design parameters; for example, choosing a CPU speed for PC customization is a parameter-based customization but choosing how fast a program runs on a PC is a need-based customization
Mechanism (Hermans, 2012)	An enabling technique to gain a high-level process flexibility needed for offering Mass Customization
Libraries of other users' design (Franke et al., 2008)	Libraries of other users' design
Selecting manufacturing and assembly method (Hermans, 2011)	Selecting how the product is manufactured or assembled
Material selection (Hermans, 2011)	Selecting material for product or part of the product
Libraries of modules and producible variants (Hermans, 2012)	Libraries of manufacturer's suggested products' variants
Side by side comparison (Randall et al., 2005)	Side by side comparison
Input type (Hermans, 2011)	The way the variable attributes are exposed based on interaction mode
Input method (Hermans, 2011)	The device or way which the data is input with
Web-based or Store-based (Nervous-System, 2020)	The place or environment that the Mass Customization happens
Offline access (AutoCAD, 2014)	The ability to access the toolkit interface and work despite of internet disconnection
Degree of freedom (Hermans, 2012)	The extent to which variable attributes can vary
Flexible navigation (Trentin et al., 2014)	Flexible navigation capability is the ability of a sales configurator to let its users easily and quickly modify a product configuration which they have previously created or the one they are currently creating

Toolkit Anatomy

Typically, the User Interfaces of Mass Customization toolkits inherit attributes from both online sales websites and CAD software programs. Recent research in the area of MC toolkit anatomy has evaluated existing configurators; Abbasi et al. (2013) considered 111 current online toolkits, while Streichsbier et al. (2009) studied 126 of them.

Previous research (Streichsbier et al., 2009; Nielson & Loranger, 2006; Abbasi et al., 2013) tried to develop a set of mexthods, guidelines, languages and tools to systemically engineer sales configurators. Streichsbier et al. (2009) research investigated whether de-facto design standards for Mass Customization toolkits exist, and if so, to identify what they are. If a given web element was designed in the same way on 80% or more websites, then this was described as a de-facto standard.

A grid-based method was employed for recording the exact position of the web objects in the 126 chosen sale configurators. Findings from this study showed that generic standards for toolkit structure do not exist, and they may only be found when the toolkits are analyzed in regard to specific industry or product type.

They also showed that there is a lack of standard or universal norms for these user interfaces, e.g., certain web objects do not have a *typical* position in toolkit interfaces (Nielson & Loranger, 2006). Therefore, there is a need to identify the positioning of the collected features, as showed in Table 1, within the screen of MC toolkits.

Research Method

The study was conducted with 30 participants — judged to be knowledgeable in the field— working in eight groups. The participants comprised of three Interaction Design Masters students, three Art Masters students and the remainder were PhD students from the Design School at Loughborough University.

The study consisted of two parts; firstly, a presentation was given by the researcher enabling participants to understand the significance of the different MC toolkit features. Any suggestions from the presentation were removed to prevent any design proposals. Most participants indicated that they understood the features very easily, as they had either used them before or they were simply very easy to be understood; e.g., side by side comparison or material selection. To support the participants when engaging in the second part of the study, and to help them remember what each feature shown in Table 1 is, the slides were scaled down and printed on small sized laminated sheets (4”x3”).

Based on the study’s objectives, two tasks were chosen among the identified methods; Card Sorting and Wireframing, to be undertaken consequently. In order to do Card Sorting, two tests were supposed to run and in order to run the tests, the collected features in Table 1 were divided into two groups. Group 1, as shown in Table 2, consists of the features that are independent. Group 2 displayed in Table 3 contains the features that can be divided into sub-features. The features in group 1, which is for test 1, need to be ranked and scored according to each other. The features in group 2, need to be sorted in their own category.

Table 2: *Independent features.*

Group 1 of features	
Visual feedback	Virtual use of object
Physics providence	Selecting manufacturing and assembly method
Users’ design access	Reference object
Technical information	Guidance (help in using the system)
Validation with feedback	Click and show option (interactivity)
Offline access	Price update
Material selection	Libraries of modules and producible
Side by side comparison	Flexible navigation

Table 3: *Dependent features – features with sub-features.*

Group 2 of features	
Mechanism (veneer, modularity, parametric, generative)	Mechanism (veneer, modularity, parametric, generative)
Need-based or parameter-based	Need-based or parameter-based
Input type (selection, drop-down menu, sliders, drawing, 3D scan)	Input type (selection, drop-down menu, sliders, drawing, 3D scan)

The intended wireframe task in this study was for finding out about the optimum layout of the MC toolkit website and where the features should generally be placed. Therefore, the participants were given a large blank sheet of paper as a representation of the website to put the feature in the area they wanted. Both tasks were undertaken by participants working in groups of 3 or 4.

Findings

The main result of this study is the features of MC toolkits’ importance ranking. This ranking (Table 4 and Table 5) is based on participants’ answers, depicted as follows:

Table 4: *Features' importance ranking in group 1.*

Rank	Feature Name	Rank	Feature name
1	*Visual feedback*	**9**	Technical information
2	*Price update*	**10**	Validation with feedback
3	*Click and show option*	**11**	Physics providence
4	*Material selection*	**12**	Offline access
5	*Flexible navigation*	**13**	Virtual use of product
6	*Guidance*	**14**	Users' design access
7	*Libraries of modules and producible*	**15**	Reference object
8	*Side by side comparison*	**16**	Selecting manufacturing method

The other group of features — group 2— are voted and ranked as below.

Table 5: *Features' ranking of group 2.*

Feature name	Votes	Feature name	Votes
Web-based or Store-based		*Input Method*	
Web-based	27		
Store-based	3	Mouse	14
Starting Point		Touch Screen	10
Template	28	Voice	3
Blank canvas	2	Haptic	2
Need-based or Parameter-based		Gesture	1
Need-based	22	*Input Type*	
Parameter-based	8		
Mechanisms		Selection	12
Modularity	13	Drop-Down Menu	9
Parametric	9	Slider	5
Generative	5	Drawing	2
Veneer	3	3D-scan	2

For exploring customer preferences regarding the on-screen location of the features, the layout generated by each group was recreated in Adobe Illustrator. The integration of the three designs into a single image was achieved by calculating the average location of each feature relative to the top left corner of the screen. This was an arbitrary coordinate center, and any other position could have been used. Figure 1 shows the overall integration of features' locations as one representation. The feature that had radically different locations were excluded from the Figure 1, including physics providence and price feedback.

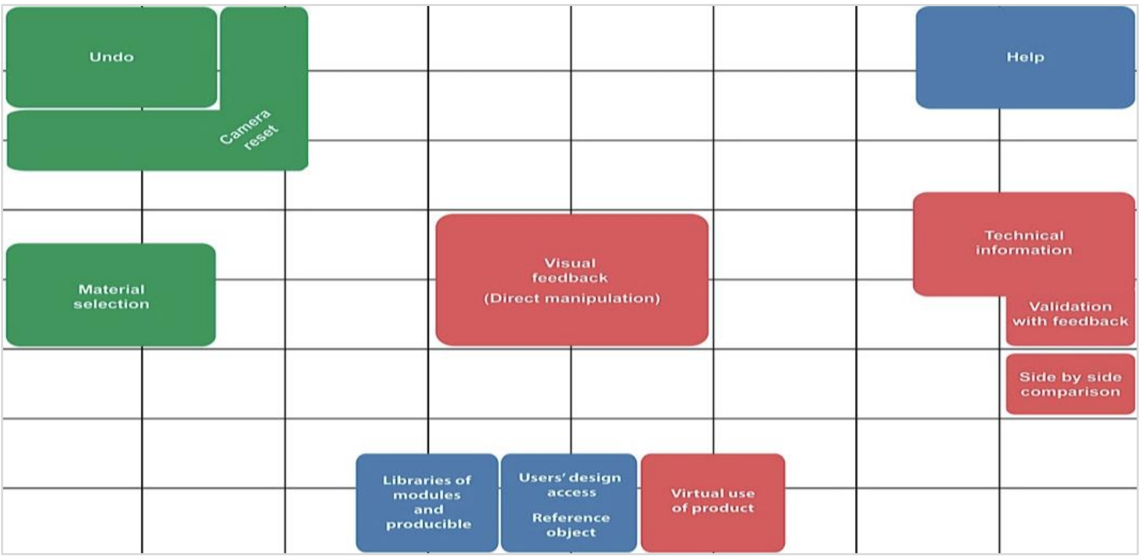

Figure 1: *Overall representation of features' location on screen based on user preferences (Red: Feedback, Blue: Guidance, Green: Navigation)*

Discussion

The findings from this study clarified the content and layout design of MC toolkits based on user preferences. The card sorting result as shown in Table 4 revealed that the most important features are visual feedback and price update, alongside with click and show option, material selection and flexible navigation. It further indicated that these top five features are essential to be included in an MC toolkit. It is very clear to see that the feature which were considered as less important in the study were not expected to be in the toolkit.

Users' design access — Libraries of other users' design — was the second least expected feature in these toolkits, suggesting this is not a highly desirable feature. This supports the contention that the uniqueness of Mass Customized products is one of the reasons for using MC (Miceli et al., 2013) and also shows that users, at least to some significant extent, do not wish to share their designs with other people for copying.

Selecting a manufacturing method was the least expected feature in MC toolkits. It can be inferred that users are not concerned with the manufacturing technique that is used for their product; or perhaps it is an issue requiring technical expertise. However, it is worth mentioning that the participants judged material selection to be the fourth most expected feature, which to some extent determines the manufacturing method employed. Therefore, it can be inferred that the material and finish of the product is of importance, however, the toolkit itself should determine the best manufacturing method for production or provide the customers with more knowledge to choose one.

As Table 5 shows, participants voted for a need-based approach (22) more than a parameter-based approach (8). This indicates that customers usually presume that the technical aspects of the products, which are customizable, are challenging. This may need further investigation if a need-based approach is preferred for almost all products even for simple ones, such as a ring or lampshade. However, this is always true that the task of translating parameters of products into needs, which is more digestible for customers, is more preferable and easier-to-use. Unfortunately, this is not usually applicable to all parameters and is not an easy task for companies.

Table 5 shows that most of the participants voted for, so preferred, a web-based toolkit (27) in comparison to store-based (3). This confirms that the advantages of web-based toolkits such as the ability to go through all the options, check the price conveniently and experiment with different configuration options outweigh the advantages of store-based toolkits. Those advantages include handling the product, seeing the colors and textures from closer and getting a sense of the final product. It is worth mentioning that these advantages and disadvantages were shown to the participants during the presentation. Furthermore, as explained before, it is predicted that 3D-enabling libraries will be used increasingly in the future, not only because they enable various features' integration, but also allow implementation of MC toolkits on the web.

Table 5 also shows that most of the participants preferred a template (28) as a starting point of customization, rather than a blank canvas (2). This shows that customers usually have the fear of creating a product from scratch and this may seem very daunting even to highly creative individuals. Additionally, customers usually do not have the knowledge to create a product from scratch, which requires a great amount of technical, engineering, industrial and manufacturing knowledge.

The integrated result for the on-screen layout design demonstrated that, based on the wire-framing result; the feature representing navigation, is concentrated on the left side of the screen, whereas the feature for guidance is scattered on the right side and bottom of the screen. Also, the feature for feedback is scattered unevenly through the center, right and bottom of the screen.

Conclusions and Future Work

The importance ranking of the selected features were obtained and analyzed. Results from the analysis indicated that visual feedback, price update, click and show option, material selection and flexible navigation were, in the order given, the most important features to be included in MC toolkits. Similarly, selecting manufacturing method, a reference object and a library of other users' designs were, in the order indicated, the least important features.

Web-based toolkits were preferred over store-based ones, a need-based approach over a parameter-based approach as well as a template starting point over a blank canvas starting point. The preferred input type based on user preferences was as follows — listed from high to low preference — selection, drop-down menu, slider, drawing and 3D-scan. Furthermore, the preferred input methods were as follows — listed from high to low preference — mouse, touch screen, voice, haptic and gesture.

The final task, wireframing, led to discovering the favourable layout for these toolkits. Layout of toolkit can help users navigate through the options easily and get useful feedback instantly when needed. The findings from this study clarified the explicitly on user-centred MC toolkit design, especially on content and layout.

More specifically, the final task concluded that the representation of a feature's location on the screen based on integration of the groups' layout design is mostly in line with the official internet usability guidelines (U.S. Department of Health and Human Services, 2006). For example, the usability guidelines state that navigation features should be included in the left panel of a webpage, whether they are primary or secondary, which is consistent with the study's results. This shows that it is more likely for MC toolkits to inherit their UI characteristics from online websites rather than CAD software programs.

What users say they do and what they actually do are often not the same (Sainio et al., 2006). Even though self-reporting and data collection based on users' self-reporting can potentially provide data relating to preferences; performance measures and observation are also needed to achieve a more comprehensive view (Sainio et al., 2006). This indicates that more empirical studies are needed in this area in which an MC toolkit is tested by users and this should be done for a variety of products to improve the generality of acquired data.

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