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ASSESSING THE VALUE OF 3D PRINTED PERSONALISED PRODUCTS

Syahibudil Ikhwan Abdul Kudus[1, 2], R. Ian Campbell[1] and Richard Bibb[1]
[1]Loughborough University, Design School, Loughborough, United Kingdom
[2]Universiti Teknikal Malaysia Melaka, Faculty of Mechanical Engineering, Melaka, Malaysia

Abstract: *As end-users become more involved in personalising designs, Additive Manufacturing has become an enabler to deliver this service through the manipulation of three-dimensional designs using easy-to-use design toolkits. Consequently, end-users are able to fabricate their personalised designs through various types of AM systems. This study employs an experimental method to investigate end-users' reflections on the value of 3D Printed personalised products based on Product Value and Experiential Value. The results suggest that end-users gave higher value to all measurements for the 3D Printed personalised products. This indicates that 3D Printed personalised products have increased perceived value when compared to standard mass-production counterparts.*

Key Words: ***Product Personalisation, Additive Manufacturing, 3D Printing, Product Value, Experiential Value***

1. INTRODUCTION

The advancement of Additive Manufacturing (AM), also known as 3D Printing, in the design and manufacturing sectors has created much attention and increasingly gained acceptance particularly from non-expert users [1], [2]. Within the consumer product market, AM is most advantageous in the environments characterised by demand for customisation and personalisation, flexibility and design complexity [3]. This movement has paved the way for 'do-it-yourself' production among individuals. They can personally design their own products through the use of AM-enabled mass customisation toolkits and fabricate them using personal desktop 3D printers or through existing 3D printing service bureaus.

Such emerging technologies present an opportunity for a new paradigm of product realisation. End-users are able to participate in the process of designing their own product through product personalisation, and are able to tailor the design of the product according to their own needs and preferences [4]. There is a wide range of consumer personalised products implemented using AM, including gadgets, home and personal accessories, jewellery, toys and artistic sculptures. According to recent researches [5], [6], many hobbyists are making use of AM with 17% of those doing so using it for consumer goods. A majority of them considered themselves beginners and most of them were making products using AM due to their passion and strong interest in AM technology.

Through AM, many personalised product design shapes can be fabricated at the same time and this makes it economical to create unique products that meet the needs of personalisation [7]. Whether it is a personalised smartphone case with a biomimicry pattern, a microcellular structure on a bracelet or a self-designed drone, product personalisation can be matched to the needs and preferences of end-users. Several studies have revealed that product personalisation can create greater benefits and increased value for end-users because it delivers a closer preference fit when compared to mass-manufactured standard products [6], [7], [8]. However, there appears to be little analysis of end-users' reflections on the value of 3D Printed personalised products, particularly to explain the benefits and values that end-users acquire when they design and own those products. Therefore, it was necessary to conduct a study to discover how AM is likely to increase the value of personalised consumer products. Value taxonomy for product personalisation was developed to be used in this study.

2. PRODUCT PERSONALISATION

Within the context of this study, product personalisation is identified as part of a Consumer Product Design approach, in which individual users engage in altering a product's form, either for functional or aesthetic reasons [11]. Within this study, the term specifically refers to the process of taking a standard product design and tailoring it to the specific needs of an individual [12]. Generally, the purpose of product personalisation is to create products that fit particular needs and that have product attributes relevant for one user at one time. Through product personalisation, end-users can exercise control over the design of a product, which requires them to operate as co-designers of their own personalised designs [13].

Mugge et al. [14] suggest that product personalisation is a promising strategy to offer end-users the opportunity to individualise their product with unlimited options. This will enable them to create products that match their identity and as a result, end-users will have more positive attitudes and higher purchase intentions due to a higher degree of design authority [15]. Nurkka [16] explains that the ability to personalise is a means of establishing a closer connection between users and products, as it enables them to determine relevant product attributes for themselves. Thus, product personalisation can provide users with superior product value. It can facilitate positive experiences, increase satisfaction with the product and meet both functional and hedonistic needs.

There is an ongoing debate among researchers and designers about how personalisation can be differentiated from customisation. There are important differences as well as similarities between the two, which could have a great impact on understanding and implementation. For the purposes of this study, personalisation is not equivalent to customisation, even though there might be little difference between them in common understanding. Campbell et al. [12] established that customisation facilitates the creation of many different versions of products aimed at different markets and the resulting products are generated by selecting from several ranges of available options. However, personalisation involves producing bespoke products that have been designed from the outset with only one customer in mind; tailoring it to the needs of an individual and nobody else.

Despite the differences between personalisation and customisation, there are also similarities between both terms. Most notably, the similarity of both terms is seen in the fact that end-users are directly involved in the process of designing a product as a co-designer. Shaukat [17] explained that personalisation is a subset of customisation, whereas co-design overlaps with both of them. In some cases, customisation activity can effectively result in personalisation, if nobody else ever chooses the same set of product options.

3. ADDITIVE MANUFACTURING AND 3D PRINTING

According to ASTM International [18], Additive Manufacturing (AM) is defined as the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methods. The term AM is often used interchangeably with 3D Printing. Reeves et al. [19] stated that 3D Printing is typically associated with people printing at home or in the community, while AM is more often associated with production technology and manufacturing supply chains. AM technology is commonly used for making physical models, prototypes, patterns, tooling components and short-run production parts. AM also has been used for series production of simple parts such as toys, novelty items, digital cameras, mobile phones, engine parts and medical implants in plastic, rubber, concrete, metal, synthetic stones, ceramic, glass and composite materials [20].

AM offers unprecedented possibilities for shape complexity and customised geometry that makes it possible for a part or product to have unlimited geometry changes at no extra manufacturing cost [21], [22]. The most interesting thing about AM is that it enables direct digital manufacturing from digital 3D models stored in a computer-aided design (CAD) file without the need for tools or moulds [23]. In this way, only a product's digital three-dimensional (3D) model is needed for fabrication and this helps product individualisation to be realised since no tooling or craft skills are needed [3]. AM can also improve a product's functionality and performance through the adoption of complex forms, user-fit requirement, producing consolidated parts and the ability to provide specific design features to increase the aesthetic value to the user [24].

Recent developments have seen a large number of companies begin to market entry-level 3D printers sold at affordable prices [25]. These machines have been priced so that they can be purchased by individuals and are capable of producing objects from a range of plastics. A personal 3D Printer can produce complex objects with minimal user intervention, making it possible for everyday users to produce physical objects at home [26]. Instead of owning a personal 3D printer, individuals may also turn to service bureaus or online retailers such as 3DHubs (https://www.3dhubs.com), i.materialise (https://i.materialise.com) and Shapeways (http://www.shapeways.com) that enable them to purchase 3D Printed items and receive them by mail. Others such as MakerBot's Thingiverse (https://www.thingiverse.com) provide free web hosting for making and sharing 3D Printable objects with online 3D Printing communities. AM and 3D Printing have proven that free-form manufacturing technology can provide high added value by playing the role of a premium production process [27]. Reeves et al. [19] have stated that AM is much more important for design firms, manufacturers and consumers because the core driver of AM is to increase geometric freedom and this approach can be used to offer product personalisation to end-users.

4. PRODUCT PERSONALISATION AND END-USER ADOPTION OF AM

Individuals may experience that realising a design idea is often difficult because they lack the skills to fabricate their personalised product [26]. End-users must be able to use accessible interfaces to control sophisticated design tools and fabrication processes, and so personal fabrication requires significant personal investment to find appropriate tools and learn how to use them [28]. 3D Printing machines and design software should be simple, have easy-to-use functions and user interfaces that enable non-expert users to control the digital design process [29].

For end-users to be directly involved in personalising a design, Shewbridge et al. [26] suggest that the adoption of fabrication tools such as 3D Printers and easy-to-use design toolkits may lower the barriers to create physical representation from an idea. The basic principle of AM is that a 3D Printable model is initially generated using a 3D CAD system. However, to create 3D Printable models is difficult for most end-users. A major issue is that it is very difficult for non-expert users to quickly design and print something, as it requires some degree of learning 3D design skills and familiarity with the technology. In addition, it is also necessary for end-users to learn about materials, design for AM, and the limitations of fabrication processes. To enable end-users to create a unique and very personal product, recent research suggests that manufacturers should create easy-to-use software platforms with which non-expert end-users can easily model a 3D object in a virtual way [4], [30]. This could open up possibilities for 3D Printing applications in consumer markets. This gap in technology has paved the way for researchers to investigate and develop consumer design toolkits and computer-aided consumer design for product personalisation through AM [31].

With such AM-enabled design toolkits, end-users can readily design and manufacture their personalised products using suitable AM systems, such as personal desktop 3D Printers. Additionally, with AM-enabled design toolkits, there will be fewer barriers for design complexity in the shape of the manufactured products, whereby, end-users could "play" and create very radical and complex patterns and shapes [32]. Existing free design toolkits such as 123D Design (http://www.123dapp.com/design), Tinkercad (https://www.tinkercad.com), CellCycle (https://n-e-r-v-o-u-s.com/cellCycle) and Project Shapeshifter (http://shapeshifter.io) offer design interfaces for non-expert users to produce their personalised designs with AM. The demand for product personalisation is expected to grow in coming years. Hu [4] has stated that with the emergence of responsive manufacturing systems such as AM and the existence of design toolkits, there will be an opportunity for product personalisation to become a new paradigm for product realisation. End-users, however, need to realise the value of product personalisation in order for them to enjoy the benefits and take advantage of the advancement of AM.

5. THE VALUE OF PRODUCT PERSONALISATION USING AM

Past investigations show that value is related to the use of an object to satisfy needs and provide benefits that end-users believe are important [33], [34]. The simple definition of value is what end-users get from the purchase and use of a product (i.e. benefits, quality, worth, utility) versus what they pay (i.e. price, costs, sacrifices), resulting in a positive or negative attitude towards the product [35]. From the end user's perspective, the value of a product does not just lie within its attributes or technical features, but also in what benefits they get from consuming the product. Researchers have identified that the consumer design process has an additional impact on the perceived value of a product. Evidence shows that even the end-users' involvement in the design and fabrication of products can in itself provide value [8], [34], [35], [36], [37].

Despite personalised AM products creating benefits in the form of better preference matching and user experience, it also brings additional cost or investment to end-users [40]. This can be in the form of investment of money, time, attention and effort during personalisation activities [8], [38], [39], [40]. Figure 1 below shows several factors that influence end-users' perceived value for personalised AM products.

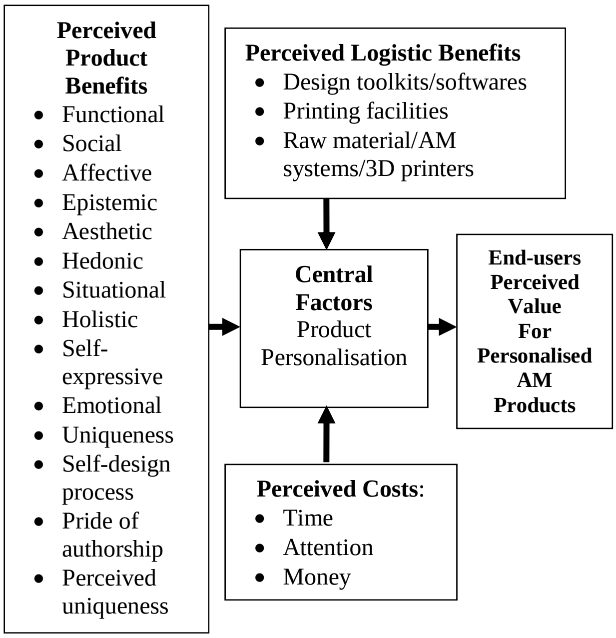

Fig. 1. A fundamental model of end-users' perceived value for personalised AM products, adapted from Schreier [34], *Lai* [41], *Aaker* [42]

End-users will see added value if the product provides a combination of additional attributes to the basic benefits such as style, durability, quality, symbolism, ease-of-use, etc. However, these types of benefits may or may not be perceived as valuable by particular end-users. This will happen only if they can perceive, appreciate and then use the product as anticipated in consumption activities to achieve their personal values [43]. As mentioned by Smith and Colgate [35], the simplest equation to express the relationship of end-users' perceived value is when the additional benefits of the product exceed any additional costs. Conversely, if the costs for the end-users to possess those products exceed the benefits, the market will not adopt product personalisation through AM [40], [45].

6. METHODOLOGY

The rationale of the study was to examine the relationships between the key value components of a personalised product using AM and the involvement of end-users in product personalisation. The 'end-user' in this study was defined as a layperson who was not professionally trained in industrial design, but were the ultimate beneficiary of the usage of the product and using it for themselves [46]. The consumer products they designed were fabricated using AM. The study was expected to shed light on end-users' perceived value of 3D Printed personalised products. A quantitative method using experiments involving participants was chosen for this study since the relative importance of social phenomenon was under investigation [47].

In order to assess the value of 3D Printed personalised products, a value taxonomy was developed to help analyse value measures obtained directly from the end-users. The proposed value taxonomy focused on identifying value that could be used to differentiate between offerings and implications that may be perceived by end-users. The conceptual value taxonomy of product personalisation using AM is shown in Figure 2 and explained below.

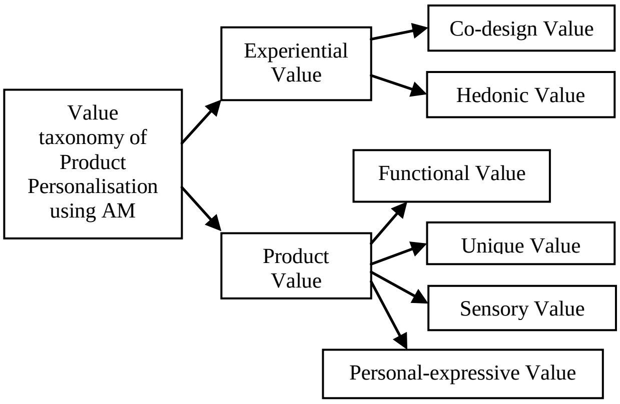

Fig. 2. Value taxonomy of Product Personalisation using AM

The taxonomy is based on the value definitions proposed by Merle et al. [37], with some additional value components required to tailor it to this study. It consists of two first-level value types; (1) Experiential Value - derived from interaction between end-users and the product personalisation process, and (2) Product Value - derived from the anticipated consumption experience. Two second-level value components are identified under Experiential Value, namely (i) Co-design Value - interaction between the individual and the personalisation activity, and (ii) Hedonic Value – the sensation of enjoyment that comes from being entertained. Four second-level value components are identified under Product Value, namely (i) Functional Value - ability to perform its function/performance, (ii) Unique Value - creation of symbolic attributes that create attention/interest, (iii) Sensory Value - reflection on beauty/sensory pleasure, (iv) Personal-expressive Value - opportunity to reflect the image and personality of a person.

6.1 Study method

Ten participants (n=10; 6 males, 4 females) who were not professionally trained in design, aged between 18 and 60 years old, and had little or no formal experience in designing using 3D Printing software and hardware were chosen for the study. The participants were chosen to represent the characteristics, attitude, opinion and behaviour of a particular population [48]. Existing easy-to-use, web-based product personalisation toolkits such as Project Shapeshifter, Tinkercad, CellCycle and 123D Design were used. Web-based toolkits were selected because they provided easy access for the participants through the internet. A Loughborough Design School-developed Lampshade Customisation Toolkit was also used in this study [32].

Three product categories were selected – household goods, jewellery and gadget. Due to budget limitations, the cost of the final 3D Printed products had to be within an overall allocated budget of £500. Therefore, products had limitations on sizes and material types. Participants attended two different sessions, (i) the product personalisation activity and (ii) product assessment and evaluation. The participants were required to complete a questionnaire at the end of each session. A descriptive statistical analysis was conducted to analyse their responses.

6.2 Fabrication of 3D Printed personalised products

Each participant produced one personalised design. Every design was carefully analysed by authors to ensure its manufacturability with the chosen AM method; in this case laser sintering (LS). The personalised products designed by the participants are listed in the Table 1 and Figure 3 shows some examples of the final products.

Table 1. *List of products personalised by participants.*

Participants	Category	Personalised products
1	Household	Lampshade
2		Fruit plate
3		Vase
4		Vase
5	Jewellery	Ring
6		Bangle
7		Bracelet
8		Cuff bracelet
9	Gadget	Raspberry Pi case
10		Refuse sack holder

Fig. 3. Examples of 3D Printed personalised products designed by participants

7. RESULTS AND FINDINGS

7.1 Experiential Value

After completing the first session, the product personalisation activity, participants completed a questionnaire to gain feedback concerning their personalisation experience. The purpose was to find out their opinions about the interaction required to personalise the design of their selected product.

7.1.1 Design attributes

Participants were asked about the types of design attributes they had considered during the personalisation process. In these questions, participants were able to select several answers that they thought were appropriate, based on their experience. The results are shown in Figure 4.

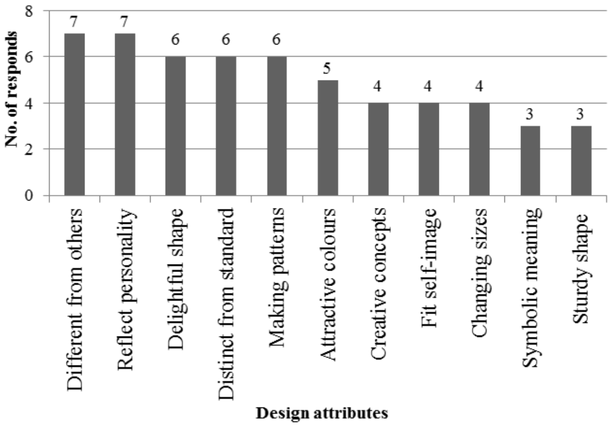

Fig. 4. Design attributes considered during personalisation process

Figure 4 reveals that most design attributes were considered by several participants during the personalisation process. The two design attributes that scored highest show that participants were looking for features that would differentiate the product from others. This response suggests that participants were looking to design a product that could be considered as having its own unique appearance, one that reflected their own personality. Figure 4 also reveals that participants also looking for a pleasant product with a delightful shapes and patterns that could improve further the appearance of the product.

7.1.2 Co-design

Participants were asked about the co-design activities that they considered when they interacted with the product during the personalisation process. Participants were able to select several answers that they thought were appropriate. Figure 5 shows the types of co-design activities that were considered by participants during the personalisation process.

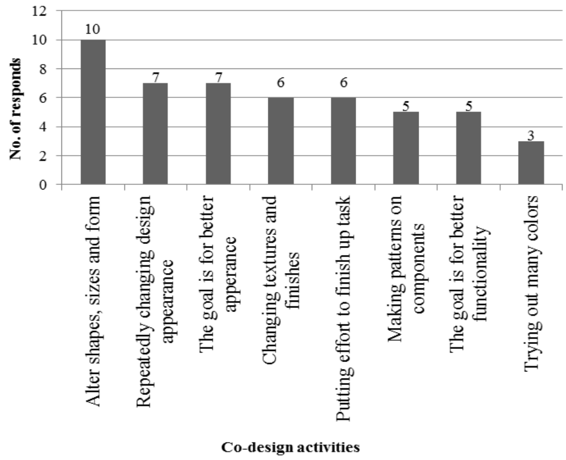

Fig. 5. Types of co-design activities considered during the personalisation process

Figure 5 shows that the participants considered various attributes during their interaction with the product. It is seen that all 10 participants were actively involved in altering the shape and form of the product, and tailoring it to the right size based on their preferences. It was also noted from observation that they repeatedly changed the component's design to improve its appearance according to their desires.

Figure 5 also reveals that the participants' goal of personalisation activity was mainly to enhance their product's appearance rather than its functionality. The responses shown in Figure 5, suggest that participants were able to interact with objects in a positive way. They tried to actively participate in the design process by involving themselves in various types of co-design activities. By playing an active role in the co-design process they were able to generate design ideas and create new design concepts. Through this activity, it has become evident that the participants were able to complete the task, design products and give expression to their own creativity.

7.1.3 Hedonic elements

To measure whether participants had developed any emotional relationship during the personalisation process they were asked about their sense of enjoyment and being entertained. Participants were able to select several answers that they thought were appropriate. Figure 6 shows the types of hedonic elements that were involved during the personalisation process.

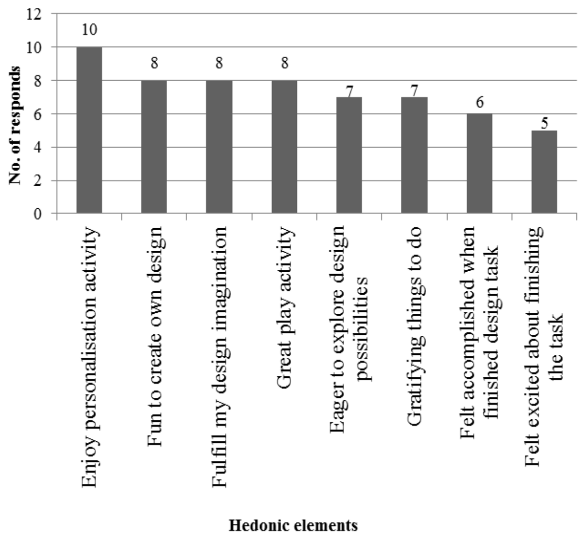

Fig. 6. Types of hedonic elements involved during the personalisation process

Figure 6 shows that participants enjoyed the co-design activities. Participants also felt that it was fun to create their own design. Product personalisation was also able to fulfil their design imagination, and equally important was that the personalisation process was perceived as an enjoyable activity. Through this feedback, it can be seen that product personalisation can elicit a sensation of enjoyment and pleasure that reflects the entertainment aspect and emotional worth of the activities. Product personalisation can be seen as one way to enable end-users to fulfil their creative desires as the activity offers almost unlimited design possibilities to be explored by the end-users.

From the experiential aspect, enjoying the personalisation process is seen as an equally important aspect of adding value to 3D Printed products. It is a process where end-users get involved in an emotional relationship when they participate in self-design activities.

It has been suggested that software developers and designers who intend to develop AM-enabled personalisation toolkits have to make sure the toolkits offer a high quality of interactive experience to end-users [49]. It is paramount for end-users to enjoy the personalisation experience in order to obtain high hedonic value from the interaction regardless of the resulting product.

7.2 Product Value

In the second session, each participant was presented with his or her 3D Printed product. Besides the 3D Printed personalised product, they were also provided with a comparable standard mass-produced product, so that they could make a comparison between the two designs. Participants completed a questionnaire to gain their feedback concerning the value of the personalised product facilitated through AM. The purpose was to find out their opinion on the value of the product from both emotional and monetary viewpoints.

7.2.1 Personalisation attributes

In the questionnaire, participants were asked about the types of personalisation attributes that had contribute to the added value of the 3D Printed personalised products. They were asked to score each of the attributes using a Likert scale of 1 to 5, where 1 was Very Little and 5 was Very Much. The scores were averaged across all participants and the results are shown in Figure 7.

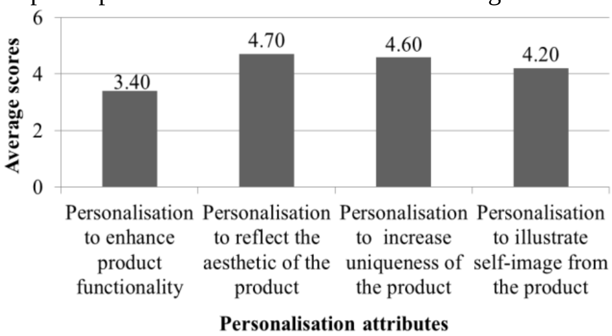

Fig. 7. Personalisation attributes and their contribution to the added value of 3D Printed personalised products

Based on the results shown in Figure 7, it seems that participants think that all the attributes are important as reflected in the high average scores. Personalisation to reflect beauty and aesthetic features of the product gained the highest average score of 4.70, closely followed by personalisation to increase uniqueness of the product at 4.60. Participants indicated that personalisation to enhance product functionality was least important with an average score of 3.40. This suggests that although 3D Printing can be used to support several aspects of product personalisation, participants are more interested in product appearance and uniqueness rather than functionality. This can be achieved by allowing them to choose their own materials, colours, personalised patterns and product shape. This high concentration on aesthetic attributes, means it is possible to achieve a high degree of uniqueness with a relatively small differentiation of design features compared to the standard product [50]. The uniqueness of a 3D Printed product gives end-users an opportunity to feel different from others as well as attracting more attention through the creation of creative shapes, beautiful colours, attractive materials, and impressive surface finish [51].

7.2.2 Participants' Perceived Value for 3D Printed personalised products

Participants were asked to make a comparison between the standard product design and the 3D Printed personalised design in order to measure their perceived value for the products. They were asked to rate their opinion of four aspects based on a measurement scale of 1 to 5. The average results across all 10 participants are shown in Figure 8.

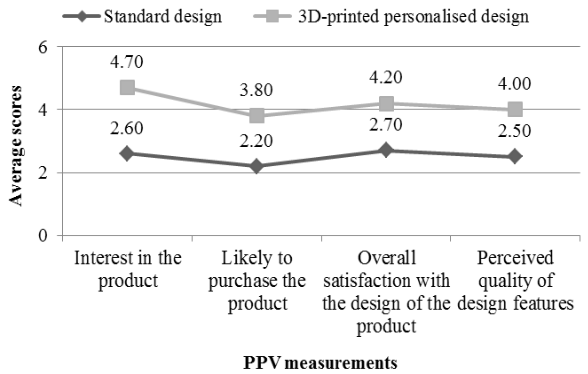

Fig. 8. Comparison of Participants' Perceived Value (PPV) between Standard Design and 3D Printed Personalised Design

Overall, the results show that participants gave higher average scores for all Participants Perceived Value (PPV) measurements for the personalised products. The largest difference between the standard and personalised products was for "interest in the product" where the personalised product score was 80.8% higher. Participants also gave high average scores for "overall satisfaction" and "perceived quality of design features". Participants gave the lowest score for both designs to "likely to purchase" with the personalised product scoring over 70% higher than the standard product. Based on the results, it can be said that participants definitely had a higher opinion of 3D Printed personalised products compared to their standard mass-production counterparts. This indicates that AM technology is able to assist in providing higher added value to the personalised designs.

7.2.3 Measuring participants' willingness to pay

The value of product personalisation was also measured through the end-users' willingness to pay (WTP) for the product [36]. During the session, participants made a physical comparison between the standard products and the personalised products. They were then asked how much they would be prepared to pay for the personalised products. In order to have a valid measurement, standard products were selected that were similar to the personalised counterparts in terms of materials, sizes, design, patterns and surface finish. The actual prices of the standard products were stated in the questionnaire and participants were asked how much more they would be prepared to pay for their personalised product. The difference between the production cost (including shipping) and the participants' WTP price yielded the value increment or decrement for each product (ΔWTP). Results for WTP measurement are shown in Figure 9, averaged for the three categories of the tested products.

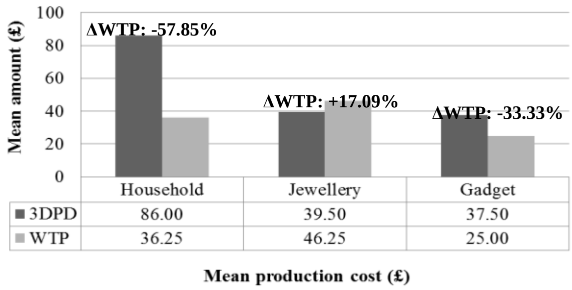

Fig. 9. Comparison between production cost of 3D Printed Personalised Design (3DPD) and participants' Willingness To Pay (WTP)

As can be seen in Figure 9, only the Jewellery category indicated a value increment with an added value of 17.09%. The mean participants' WTP was £46.25, while the mean production cost for the 3D Printed products was £39.50. This indicates that participants were willing to pay an average of £6.75 more than the production cost. However, the other two categories, Household Goods and Gadgets both show significant negative values of -57.85% and -33.33% respectively. This indicates that in the Household Goods and Gadgets categories, the increased perceived value for the personalised products was not enough to justify the increased 3D Printing production costs.

7.3 The key value of 3D Printed personalised products

To assess the key value drivers for 3D Printed personalised products, participants were asked to rate their opinion of various statements. These statements explained the characteristics of product personalisation that are facilitated by AM technology and were based on the value components that were developed in the value taxonomy. By using a Likert scale, participants could express their opinions by rating the statement from Strongly disagree to Strongly agree (1-5 rating). The results indicated how strongly each value component contributed to the overall increase in value associated with product personalisation (see Figure 10).

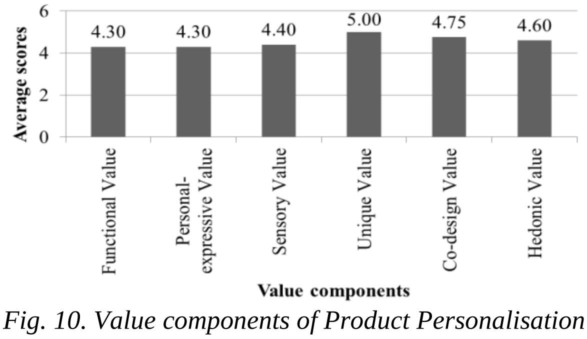

Fig. 10. Value components of Product Personalisation fabricated through AM/3D printing technology

In general, the results show that participants gave high average scores to all the value components. This indicates that participants regarded all the value drivers as being important. Unique Value is seen to have highest average score of 5.00, closely followed by Co-design Value at 4.75 and Hedonic Value at 4.60.

From the viewpoint of Product Value, the results suggest that personalised products fabricated using AM technologies are able to provide high unique value to end-users. This is because personalised AM products can express symbolic attributes that create interest and draw attention to an individual person [36], [50], [51]. This results in the creation of product differentiation, i.e. not looking like anyone else’s product and being exclusive to an individual. This is supported by the ability of AM to produce highly complex forms, its flexibility for part fabrication and its ability to provide specific design features according to end-users’ desires. These attributes are not sufficiently supported by traditional manufacturing systems, which typically produce large numbers of identical products. The achievement of high unique value also correlates with the key motivation of product personalisation, i.e. to acquire distinct design features by producing bespoke products that are tailored to end-user’s specific needs.

The results also indicate that product personalisation through AM is also able to provide high Experiential Value to end-users. High Experiential Value can only be obtained when end-users play an active co-creating role throughout the personalisation process through asserting their skills in making the designs using their own hands [52]. From the opportunity to co-design the products, end-users could derive enjoyment from their active participation during the personalisation process. This value may also have been partly gained from the feeling of accomplishment when they obtained the final products from the personalised designs [10]. Supporting mechanisms such as AM-enabled design toolkits must be able to achieve high hedonic value by making the personalisation process an enjoyable activity able to fulfil users’ creative imaginations.

8. CONCLUSION

This study has attempted to shed light on end-users’ perceived value of a consumer product design being personalised and fabricated using AM technology. It has done this by examining the definitions, concept and measures relevant to value in consumer product design. Based on the results obtained, it can be concluded that through end-users’ involvement in personalising a consumer product, they were able to acquire added value by producing a bespoke product that was tailored to their individual needs and preferences and no one else’s. End-users who take the opportunity to get involved in the process of creating their own designs and take advantage of the advancement of AM technology enable them to enjoy a positive co-design experience that embodies personal taste and style [32].

This study also showed that AM is a key tool for producing the unique designs created through product personalisation. Supported by AM-enabled design toolkits and suitable materials, personalised AM products can bring “freedom of expression” to end-users by creating physically exciting products that suit their individual needs or desires. The end-users themselves can identify which types of value aspects they want to add depending on the purposes and types of product they personalise.

A major limitation found from the study was that fabricating a product using AM technology requires a higher financial investment from users. The study showed that end-users were not willing to pay very much more for a personalised AM product compared to a mass-produced product. Therefore, although personalisation added value in two out of three product categories, the extra amount they were willing to pay was not enough to cover the extra cost of 3D Printing. It will be necessary for system providers and service bureaus to reduce costs to stay within the extra willingness to pay price if 3D Printed personalised products are to become popular. This might be addressed as the quality of AM parts approaches the quality of familiar mass-produced items.

The lessons learnt from this study will pave the way for the development of an added value identification methodology for product designers. It will enable them to identify the design features in a product that will potentially add value if the product were to be personalised and fabricated using AM. It will act as a design support tool to aid designers in providing value adding "personalisation features" in order to satisfy end-users' individual needs.

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CORRESPONDENCE

Syahibudil Ikhwan Abdul Kudus
Loughborough University
Loughborough Design School,
LE11 3TU Loughborough,
Leicestershire, UK
s.i.abdulkudus@lboro.ac.uk
syahibudil@utem.edu.my

Dr R Ian Campbell
Loughborough University
Loughborough Design School,
LE11 3TU Loughborough,
Leicestershire, UK
r.i.campbell@lboro.ac.uk

Prof Richard Bibb
Loughborough University
Loughborough Design School,
LE11 3TU Loughborough,
Leicestershire, UK
r.j.bibb@lboro.ac.uk