TEMPLATES FOR CONSUMER USE IN DESIGNING CUSTOMISED PRODUCTS

Y. Ariadi and A.E.W. Rennie
Lancaster Product Development Unit, Engineering Department, Lancaster University, Lancaster, LA1 4YR, UK.

Reviewed, accepted September 10, 2008

ABSTRACT

This research proposes a new design system for consumers who would use the product to run an easy-to-operate design and selection tool by themselves instead of conventional Computer Aided Design (CAD). In terms of manufacturing the product, several studies focus on involving the consumer as much and as early as possible. However, recent developments of Additive Layer Manufacturing (ALM) technologies have led to a renewed interest in allowing the consumers to develop customised products. As a result, manufacturing is being brought closer to consumers. This paper would simplify the CAD stages by utilising design templates for consumer use in customising additive layer manufactured products.

KEYWORDS

Computer Aided Design, Design Template, Additive Layer Manufacturing, Mass Customisation, Product Family Architecture

INTRODUCTION

The design template is a simple program containing a database of Product Family Architecture (PFA), which allows consumers to configure the features or aspects of a products design and/or to individualise it and it should be easy-to-operate for specific products. In addition, the PFA must represent the ALM capability and the resultant output that can be realised by the specific ALM technology chosen for manufacturing the final desired product.

Research to date tends to focus on the consumers' view rather than manufacturers' view. Most studies in the manufacturing field use the conventional approach by bringing the consumers' voice into the design and manufacturing processes [1]. This paper will use an inverted approach by bringing design and manufacturing to consumers, which allows consumers to be party to the design and manufacture of their products. For several decades, industries have shifted from production-driven and market-driven approaches to consumer-driven approaches. It connects consumers' choices with the capabilities of the company, and extends the philosophy of concurrent engineering to sales, marketing and end users [2]. In the future, some manufacturers of commercial products might allow consumers to make their own products. For instance, in the past, consumers had to visit specialist photographic retailers to have their photographs printed, but now they can do the printing themselves, directly and easily, on printers at home. In the future, they would be able to print not only 2D products, but also 3D shapes [3].

The widespread use of the Personal Computer and its peripherals, as well as the internet and e-business has affected the behaviour of many consumers [4]. Additionally, it also allows easy and fast communication between the manufacturers and consumers so the manufacturer can grasp the consumer requirements, while the consumers express their particular needs [5]. In this way, consumers are accustomed to conveying their ideas, so the numbers of consumers who want to have their individual items will inevitably increase [6].

BACKGROUND AND AIM OF DESIGN TEMPLATE

Consumers' behaviour and customisation

Inner characteristics are defined as specific qualities, attributes, traits, factors, and mannerisms that distinguish one individual from other individuals. In other words, the individual's personalities are a unique combination of factors and no two individuals are exactly alike [7]. Consequently, the needs for customisation have increased from 6% (1997) to 30% (2005). It had been surveyed for some consumers' products such as computers, shoes, toys, bags, clothes and mail. Furthermore, consumers do not only require the individualisation of products, but also want to design their own items and to tailor them [8].

Nowadays, companies have to adopt strategies that embrace both a closer reaction to the consumers' needs and efficiency. Mass customisation (MC), first conceived in 1987 [9], meets this challenge by offering individually customised goods and services with mass production efficiency. It refers to the customisation and personalisation of products and services for individual consumers at a mass production price. When the needs of custom products have increased in the market, many companies use MC as a strategic business operation. It has become an important trend in the manufacturing industry towards market globalisation, rapid technological innovation and intense competition [6, 10]. Thus, the capabilities to produce customised products, which are matched to the specific individual needs, are expected to have a major beneficial impact on the quality of life [11].

One of the methods to achieve MC is through using Product Family Architecture (PFA). This is defined as a group of related products that share common features and or components and fulfils the need of niche markets. The product platform is a set of parts, subsystems, interfaces, and manufacturing processes that are shared among a set of products [12]. In this methodology, manufacture can offer its capability to match consumer needs through the configuration database. It contains a variety of product families and performs as a generic product platform for product differentiation in which individual consumer requirements can be satisfied through systematic decisions of developing product variants. Much research in these particular areas set the PFA as a representation of industries' capabilities [2].

However, in this study, all features must be able to be created by using ALM technology. Moreover, this report interfaces the PFA and is used as a software accompaniment to the ALM machine.

User-friendly CAD for customisation

CAD has passed through a long era where it was perceived that only engineers were able to operate the software, as the operation of CAD required lengthy specialist training, and the ability to understand sequences of commands to create or modify digital data. These days, this is not entirely the case.

The CAD industry has diversified its scope (Figure 1); it has achieved this by making CAD more detailed and specific for specialists, for example the invention of Piping CAD and Electrical CAD [13]. CAD has also become more user friendly, by implementing simplified and easy operational procedures (SpaceClaim [14] and Google Sketchup [15]). Further, for special interest/hobbies or art works, CAD can enable customisation in the design level and thus, bringing consumers close to designing (e.g. of such special CAD software are BikeCAD [16], Figureprint [17] and Wizaray-R [18]).

In addition, many researchers have made CAD easy by combining pen and tablet to facilitate freehand sketching to construct a 3D design [19], as well as combining with Haptics to shape a 3D virtual surface [20]. Thus, with such developmental progress, CAD has taken one step further to becoming a stylish designer tool.

However, these technologies approach the designers' needs, rather than consumers' needs. The website Ponoko [21], fulfil the needs of consumers who want to turn their idea into a product [22], though it is limited for 2D products only and utilises 2D design software. For the creation of design tools for consumers in producing 3D products, this study will propose a simple program and no costly devices to help consumers design their ideas.

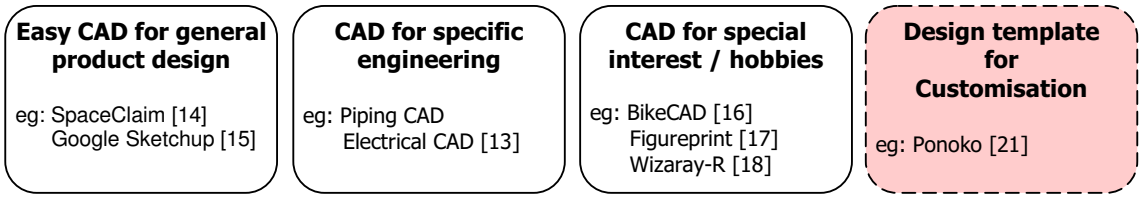

Figure 1: The purpose of CAD and Design Template

Virtual Reality (VR) technology, as a visualisation tool, immerses people into reviewing many aspects of a design, e.g. shape, structure, and function of the product, well before the product is manufactured. Moreover, it has left out the physical prototyping process. Simple VR has been used as the virtual product where the end user can assess the suitability of a design. Supported by the PFA and the internet, consumers can take part in the product design and link their demand to industries' offerings [23]. In the same context, the design template, presented by this research, offers ALM facilities as well as reviewing the final design.

ALM for ultimate customisation

ALM is one of the most significant current manufacturing technologies that vastly expands the opportunities and has positive impact on the way we manufacture products. In addition, additive processes, which generate parts in a layer-upon-layer fashion, have more than 20 years of history. In its formative years, the purpose of these technologies was to make prototypes, but now it is no longer exclusively used for prototyping. In recent years, one has observed a move from Rapid Prototyping (RP), to Rapid Tooling (RT) and then to Rapid Manufacturing (RM) [24].

According to a survey by Piller, ALM is driven by the general MC trend where 28% of those interviewed said that the trend towards individualised series production is the most important factor for the success of the technology. Both industry and end consumers increasingly request individually manufactured products, creating a potential demand for MC of those products. At this point, ALM technologies come into their own in the facilitation of such individualisation [25]. New opportunities and applications in appropriate manufacturing tasks are opening up, even though the economic impact is still modest. The ALM machine is now becoming affordable to small businesses and potentially to the individual consumer [24, 26]. Moreover, processes such as 3D printing, show that this technology is easier to use, relatively inexpensive to operate and office friendly [27].

In addition, the advancements of ALM technologies would also bring production to the next era of MC, namely Ultimate Customisation (Figure 2). It will involve much greater personalisation, where consumers actively take part as co-designers and thus contribute to the value creation [28]. Consequently, manufacturing has taken several steps closer to consumers (Figure 3).

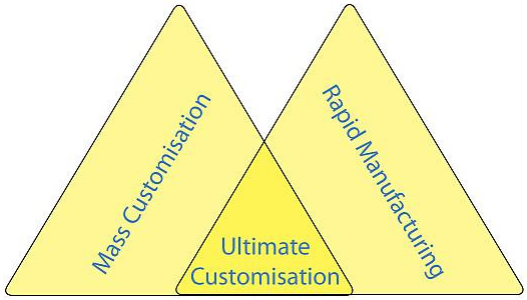

Figure 2: Ultimate customisation [28]

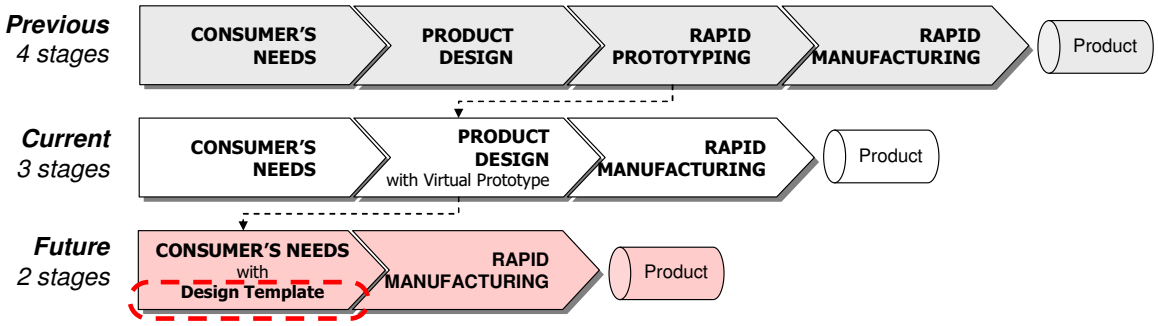

Figure 3: Reducing the production stages to realise ultimate customisation

RESEARCH DESIGN

Research opportunity

With such developments, CAD has taken one step further to become a stylish designer tool, where previously only the design engineer used it (Figure 4). As they do in physical model, the virtual clay system allows designers to easily create, modify and evaluate shapes of products by interacting with a virtual model through a Haptic tool operated with their hands [20].

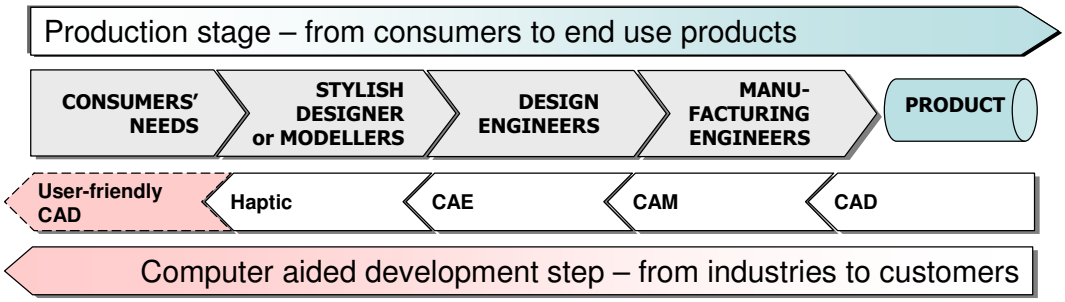

Figure 4: CAD/CAM/CAE/Haptic progression

With regards to the background of ALM advantages and to bring manufacturing closer to consumers, the research to date tends to focus on extending the CAD to consumers as users. To overcome the problem, an easy-to operate design tool is needed so that the consumer is able to carry out any design personalisation or customisation according to their individual desires and taste. This research proproses to fulfil a gap between existing CAD and non-technology compliant users, in the other words, to create easy CAD for consumers in designing specific products.

Design template system architecture

Figure 5 displays the simple design template, which provides PFA. With this design template, users do not only choose the part but also can determine the features on the part. It is similar to some shoe manufacturers who serve consumers on their websites by allowing them to decide on the colour theme that they desire, place or locate logos and apply their own text [29].

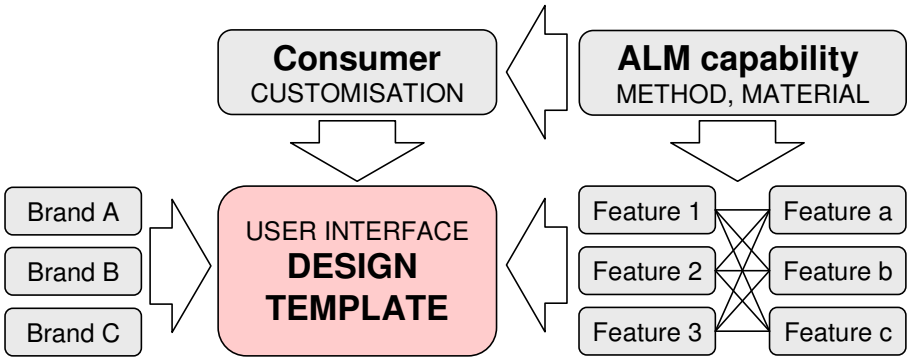

Figure 5: Simple design template

Previous studies have recommended that personalisation needs powerful Web Intelligence (WI) technologies to manage, analyse and employ various data on the web. WI exploits Artificial Intelligence (AI) and advanced Information Technology (IT) on the web and internet. Common applications using WI techniques for e-business are to find patterns of user behaviour and to provide online consumers with personalised services [30, 31].

This research interfaces the database and features with simple html format and the 3D modelling database created by SolidWorks Publisher. So, consumers are able to decide and review the final design by rotating and panning it without the need for costly CAD software.

Design template for mobile phone cover

The research will take a case study of manufacturing the cover of a mobile phone (Figures 6 and 7) which can be manufactured using ALM technology and customised if and where appropriate. Three brands of each kind of device will be chosen as an example. For the device covers, consumers will be offered features as follows: Option 1 is sock type where the consumer can lay a lithophane (image), logo or name in front of the screen; Option 2 is fit type, i.e. it can have a flip screen cover or not, and as in Option 1, it is possible to place graphics on the screen cover or print text as well.

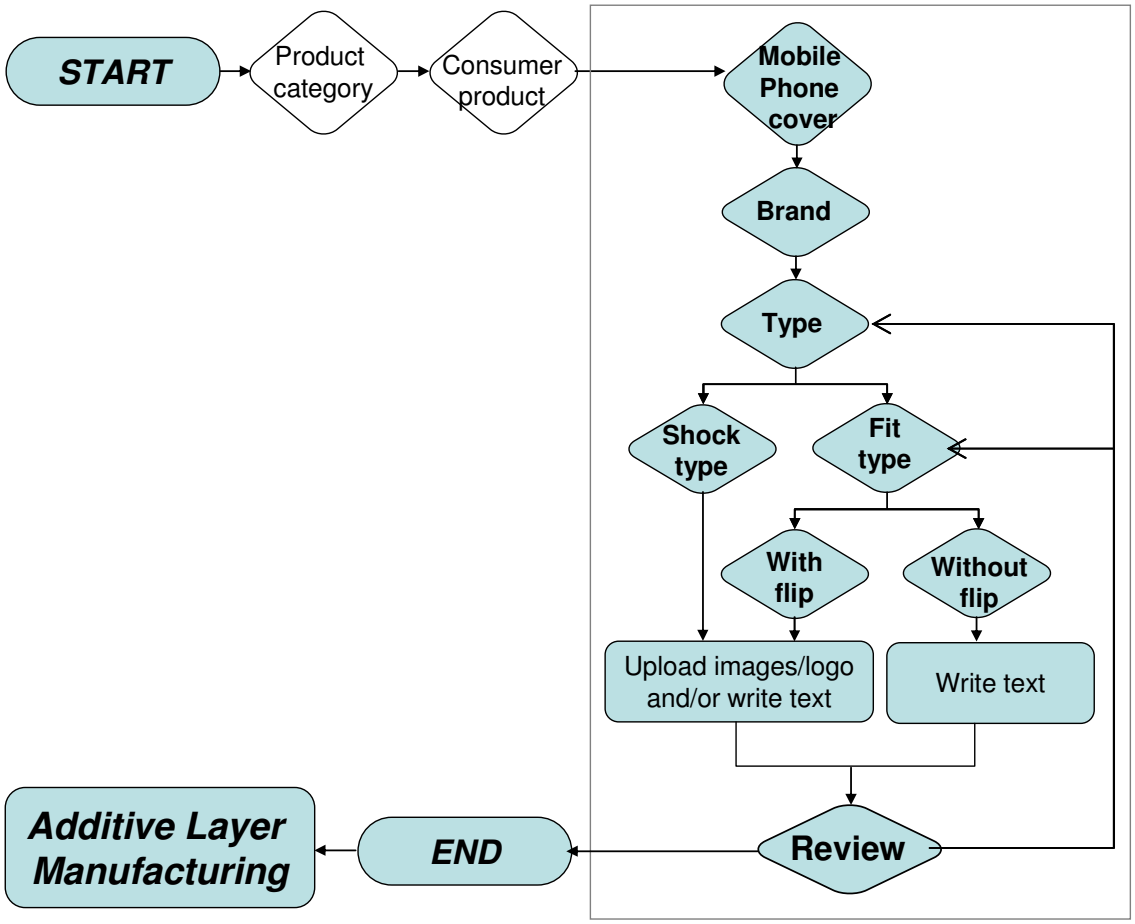

Figure 6: Flow process of Design Template of mobile phone cover

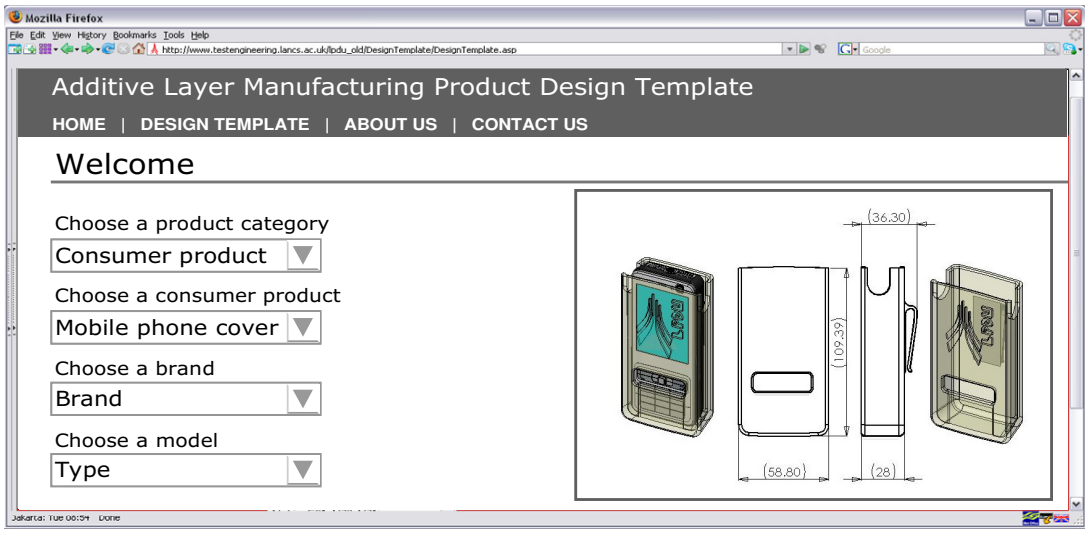

Figure 7: Design template of mobile phone cover [32]

It follows that the 3D model will appear and the consumer will evaluate whether the product is ready to be manufactured or go back to the previous step.

CONCLUSION AND FUTURE WORK

In regards to the view of consumers, the ALM machine has to be tried as a home appliance or in a small office so that a user-friendly design template system can be developed. PFA, as a part of the design template, represents the capability of ALM, whereas it is usually used as a representation of the industries capability.

The design template could be employed by consumers as the software that goes along with the ALM hardware. Furthermore, it could also be used by Small Medium Enterprises (SMEs) who produce specific products and repeat their designs for a wide range of variants.

This research suggests that the Design Template has the capability for customisation e.g. by placing Lithopane images and/or text on the screen cover; and printing 3D models on ALM machines. However, the interface between Design Template, customisation features (uploading photo/image/logo, texting) and pre-manufacturing process (creating STL file) still needs to be developed in the future.

Similarly, patterns with manufacturing that have stepped closer to consumers and in line with the MC trends, design aspects should also be developed to become closer to the non-technology compliant or inexperienced users and SMEs. As a result, the use of design templates for specific products would grow widely. With regards to Open Source Software and the internet social networking trends [33, 34], it would be appropriate to create a Portal for ALM Design Templates to accommodate the design templates of other specific products. For this reason, the portal should be able to accommodate other parties to upload their product design templates.

ACKNOWLEDGMENTS

This research is part-funded by the European Regional Development Fund *Rapid Manufacturing North West Project* and the Higher Education Innovation Fund. The authors wish to acknowledge the input of Dr Phil Reeves of Econolyst Ltd in the support of this Project and its activities. Additional thanks are also extended to Vatsala Nundloll-Ramdhany of Lancaster University for programming of the design template and Adrien Grouhan from the University of Brest, France, for 3D modelling input.

References

1. Clausing, D.P., *Total Quality Development A Step by Step Guide to World Class Concurrent Engineering*, ed. K. Ragsdell. 1998, Mexico: American Society of Mechanical Engineers (ASME). p.506.
2. Tseng, M.M. and Du, X., *Design by Customers for Mass Customization Products.* CIRP Annals - Manufacturing Technology, 1998. **47**(1): pp.103-106.
3. Malone, E. and Lipson, H., *Fab@Home: the personal desktop fabricator kit.* Rapid Prototyping Journal, 2007. **13**(4): pp.245-255.
4. Mullaney, T.J., Green, H., Arndt, M., Hof, R. D., Himelstein, L., *The e-Biz Surprise.* Business Week, 2003(3832): pp.60-68.
5. Brockhoff, K., *Customers' perspectives of involvement in new product development.* International Journal of Technology Management, 2003. **26**(5/6): pp.464-481.
6. Piller, F. and Kumar, A., *For each, their own.* Industrial Engineer: IE, 2006. **38**(9): pp.40-45.
7. Schiffman, L.G. and Kanuk, L.L., *Personality and Consumer Behavior*, in *Consumer Behavior*. 2007, Pearson Prentice Hall: New Jersey, USA. p.116.

8. Silver, M. and Hallett, V., *Satisfied Customizers.* U.S. News & World Report, 2005. **139**(19): pp.D2-D6.
9. Davis, S., *Future Perfect*. 1987: Addison Wesley Longman Publishing Co. p.243.
10. Piller, F.T. and Muller, M., *A new marketing approach to mass customisation.* International Journal of Computer Integrated Manufacturing, 2004. **17**(7): pp.583-593.
11. Gerrits, A., Jones, C.L., and Valero, R., *Custom Fit: A Knowledge-based Manufacturing System Enabling the Creation of Custom-Fit Products to Improve the Quality of Life*. in *RPD 2004-Rapid Product Development*. 2004. Portugal.
12. Meyer, M.H. and Lehnerd, A.P., *The Power of Product Platforms: Building Value and Cost Leadership*. 1997, New York, NY 10020: The Free Press. p.39.
13. Goldberg, E.H., *Today's Plant and 3D plant design*, in *Cadalyst*. 2002. p.10.
14. Available from: http://www.spaceclaim.com/. [Last accessed 21 May 2008].
15. Available from: http://sketchup.google.com/. [Last accessed 28 May 2008].
16. Available from: http://www.bikeforest.com/CAD/. [Last accessed 24 May 2008].
17. Available from: http://www.figureprints.com/. [Last accessed 24 May 2008].
18. Available from: http://www.chubu3d.com/WizR_top.html. [Last accessed 13 July 2008].
19. Masry, M., Kang, D. and Lipson, H., *A freehand sketching interface for progressive construction of 3D objects.* Computers & Graphics, 2005. **29**(4): pp.563-575.
20. Bordegoni, M. and Cugini, U., *Create free-form digital shapes with hands*, in *Proceedings of the 3rd international conference on Computer graphics and interactive techniques in Australasia and South East Asia*. 2005, ACM: Dunedin, New Zealand.
21. Available from: http://www.ponoko.com. [Last accessed 12 July 2008].
22. Gibson, M.P. *Automated Custom Manufacturing: Ponoko wants to give customers the tools to design and sell whatever they want.* 07 November 2007. Available from: http://www.technologyreview.com/Biztech/19678/?a=f. [Last accessed 13 July 2008].
23. Dai, K., Li, Y., Han, J., Lu, X., Zhang, S., *An interactive web system for integrated three-dimensional customization.* Computers in Industry, 2006. **57**(8-9): pp.827-837.
24. Levy, G.N., Schindel, R. and Kruth, J.P., *Rapid Manufacturing and Rapid Tooling with Layer Manufacturing (LM) Technologies, State of the Art and Future Perspectives.* CIRP Annals - Manufacturing Technology, 2003. **52**(2): pp.589-609.
25. Piller, F. *Industry Study on State of Rapid Manufacturing and the Future of Production*. 02 February 2008. Available from: http://mass-customization.blogs.com/mass_customization_open_i/2008/02/industry-study.html. [Last accessed 13 July 2008].
26. Anderson, P. and Sherman, C.A., *A discussion of new business models for 3D printing.* International Journal of Technology Marketing, 2007. **2**(3): pp.280-294.
27. Available from: http://web.mit.edu/tdp/www/index.html. [Last accessed 25 May 2008].
28. Eyers, D. *Ultimate Customization: Design and Deliver - a new project that examines the next era of mass customization*. 27 April 2008. Available from: http://mass-customization.blogs.com/mass_customization_open_i/2008/04/ultimate-custom.html. [Last accessed 13 July 2008].
29. Available from: http://www.nikeid.com. [Last accessed 8 April 2008].
30. Zhong, N., *Toward Web Intelligence*, in *Advances in Web Intelligence*. 2003. p.955.
31. Ji, J., Liu, C., Sha, Z., Zhong, N., *Personalized Recommendation Based on A Mulrilevel Customer Model.* International Journal of Pattern Recognition & Artificial Intelligence, 2005. **19**(7): pp.895-916.
32. Available from: http://www.lpdu.lancs.ac.uk/lpdu/DesignTemplate/index.html. [Last accessed 14 July 2008]

33. Ajila, S.A. and Wu, D., *Empirical study of the effects of open source adoption on software development economics.* Journal of Systems and Software, 2007. **80**(9): pp.1517-1529.
34. Look, D., *Fostering Design Software Ideas*, in *Design News*. 2008, Reed Business Information. p.14.