Review of Product Design and Manufacturing Methods for Prosumers

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Abstract. Product design is a process developed by specialized profiles such as designers or engineers. For this reason, most of product design and/or manufacturing methods developed are aimed at experienced professionals. However, in the current social and technological context, we observe that the number of *prosumers*, users who partially produce the products they consume, is increasing. These users are involved in design, manufacturing or assembly phases of the product to obtain final results that respond to specific needs and desires. Given this emerging trend, we wonder if there are methodologies focused on these users in particular, both in the academic field and in practice. This work aims to clarify this issue through a review of research papers and real cases. The results obtained differentiate between the methodologies that have been defined in the academic field and those that have not been compiled but whose repeated use has agreed its application and existence in practice. The methodologies identified are analyzed in two tables that summarize how they are applied and what their main objective is. The results and conclusions offer both the scientific community and the prosumers a series of product design and manufacturing methods focused on non-specialized profiles.

Keywords: Prosumer · Product design · Methodology · Manufacturing

1 Introduction

The multiple advances that have taken place in fields such as Information and Communication Technologies (ICT) or Agile Manufacturing [1], as well as the democratization of the creative process and its approach to non-specialized users [2], have resulted in an increase in *prosumer* users. These types of users, according to the original definition of Alvin Toffler, are those who are involved in the design, assembly or manufacturing process of the products they finally consume [3]. That is, they are consumers of what they produce.

This emerging trend, closely related to the maker culture, without being the same, has made increasingly users decide to design or manufacture their own products. However, its intervention is not restricted only to the previous phases of the product's life cycle. An example of this is *hacker* users, who also make modifications to make the product grow and obtain new functionalities that they did not have before [4]. For this reason,

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the number of both physical and digital tools set aside for this purpose has increased exponentially in recent years [5, 6], causing many users to use them frequently unconsciously. These tools are not only intended for individual use, as we can also find tools such as consumer-based coopetition, crowdsourcing and value co-creation [7].

However, despite the number of tools available, there is a lack in the definition of design and manufacturing methodologies focused on prosumer or maker users. Although there are co-design methods that include the participation of experts and end users, their application is only carried out in the phases of product design and development and they are not adapted to each particular user, but they take into account the opinion global to implement improvements. In addition, it has been detected that, in actual practice, there are a number of consolidated methods that are frequently used by prosumers to intervene at different levels in the design or manufacture of their products [8]. For these reasons, this article aims to clarify which methods specifically focused on this type of users currently exist, both in the academic and practical fields.

2 Methodological Description

The main objective of this study is to collect and analyze the design and manufacturing product methods focused on prosumer users that have been developed until now. To achieve this, the study is divided into two parts: a bibliographic analysis and a field study. The bibliographic analysis shows works published in the academic field that deal directly with this type of methods, while the field study is based on real cases that prove the existence of consolidated methods frequently used by prosumers.

To perform the bibliographic analysis, a search was carried out in various databases (Web of Science, Scopus, Wiley Online Library, Science Direct) by combining two keywords: first, about prosumer user (*end user*, *co-design*, *maker*, *lead user*, *design manufacturer*); and, second, in reference to the design or manufacturing method (*method*, *methodology*, *tool*, *guideline* + *product design*, *manufacturing*). Due to different definitions of prosumer, the search was skewed, discarding the results related to *professional consumers* or *self-consumption*, especially in relation to the production of electricity. Methods that are focused only on specialized profiles (as designers) or co-creation processes where the users involved are not those who finally consume the product or service created, were also ruled out.

On the other hand, the field study is based on a previous work carried out within this line of research that compiles real cases of prosumer users [9]. This study shows various real cases in industrial fields such as furniture, textile and electronic, among others, where it is detected that we can define methods based on the use of common tools and processes between them.

Final results have been synthesized and compared in tables, that includes a description of each method, as well as its objective and main data. A total of 15 methods have been identified: 9 corresponding to the bibliographic search and 6 to the case analysis. Finally, this work offers a series of conclusions about the current design and manufacturing methods for the prosumer, including the opportunity to any new prosumer or maker to have enough information to join this trend.

3 Results

The results have been divided into two parts: *methodologies* and *real cases*. The basic information necessary to understand each methodology separately has been included in Table 1 (bibliographic analysis) and Table 2 (real cases). In the field study we find several examples for each methodology. However, only one representative case has been cited in each one in order to serve as an example of application to facilitate its understanding to the reader.

To facilitate the visualization and comparison of academic methodologies, these are grouped and summarized in the same table that shows the name of each methodology, the author and year of creation, a brief description and what is its main objective: Product Design (PD), Manufacturing (M) or Assembly (A).

Table 1. Summary of academic methodologies.

Name	Author and year	Description	Objective
Method to work with end users to create personalized products by CAD modelling	Campbell and Bernabei, 2017 [10]	To increase product emotional attachment through custom design of additively manufactured products	PD + M
Lead-User Method	Franke, Von Hippel, and Schreier, 2006 [11]	Theory upgrade to exploit the value of user innovations	PD + M
User-centered translation method	Gardan, 2017 [12]	It includes the user in the design process by basing on their perception of the product	PD
Guidelines for Finding Lead User for Latent Need Discovery	Hölttä-Otto and Raviselvam, 2016 [13]	To find Lead-Users to express latent needs that are not found in regular users	PD
Mixed reality tool for end-users participation in early design tasks	Maurya, Arai, Moriya, Arrighi, and Mougenot, 2019 [14]	It allows end-users to be immersed in a virtual environment, to interact with a virtual prototype and to modify it	PD
New Service Development Method for Prosumer Environments	Alcarria, R., Robles, T., Dominques, A.M., Conzales-Miranda, 2012 [15]	To develop prosumer services by providing creation tools, used by prosumers to create final services	PD (Service Design)

(*continued*)

Table 1. (*continued*)

Name	Author and year	Description	Objective
Method to optimize assemblability of industrial product in early design phase	Favi and Germani, 2012 [16]	To create adaptable and customizable products by improving manual assembly through modular design	PD + A
Using elderly as lead users for universal engineering design	Raviselvam, Noonan, and Hölttä-Otto, 2014 [17]	The main idea is that, the elderly may be able to articulate more needs compared to general population	PD + M
Design Evaluation and Assessment System	Morita, 2007 [18]	It allows makers (designers, technicians), providers and end-users to evaluate products using the same criteria	PD

In the following table (Table 2), a series of methodologies based on the study and analysis of real cases are cited. Each methodology is based primarily on the use of a digital or physical tool that allows users to intervene in the design or manufacturing phase of the products that they subsequently consume.

Table 2. Summary of methodologies based on real cases.

Name	Case	Description	Objective
Online Platform to interchange ideas	Ikea Hackers [19]	Users contribute new ideas and modifications on designs that they then share and manufacture	PD + M
Design Software, 3D and CAD software	Vectary [20]	It allows to visualize and materialize a design by using tools such as 3D modeling	PD + M
Tutorials and instructions	Instructables [21]	These are steps to copy, manufacture and assemble the product, although the user can also influence its design including modifications	M + A

(*continued*)

Table 2. (*continued*)

Name	Case	Description	Objective
Open Source, Cloud and Co-design	Ordermade WholeGarment [22]	Free access tools where users share files on which other users can intervene (co-design)	PD
Vote System and crowdfunding	LEGO Ideas [23]	Collective participations to take design or market decisions about a product before its manufacture and commercialization	PD
Observation, analysis, trial and error	Maker Faire [24]	Extended method in the maker culture based on observing and analyzing a product, to modify it by trial and error	PD + M + A

4 Conclusions

The bibliographic analysis shows nine methods focused on the prosumer with different objectives: to increase the attachment of the product, to exploit the value of users' innovations, to take into account the user's perception, to discover latent needs, to improve the prototype, to evaluate the product and to create adaptable and customizable results. Most of them look for product improvement to obtain a greater final acceptance in the market, only two take into account the real interests of the prosumer: the search for latent needs and the creation of adaptable and customizable products. Furthermore, the nine methods focus on product design and only four of them also focus on manufacturing (3) and assembly (1).

The analysis of cases has allowed to identify a series of methods based on tools because, although the prosumers and makers do not recognize the use of any specific method, the use of tools among them is highly agreed. Therefore, six methodologies can be clearly defined: exchange of ideas on online platforms; 3D and CAD design software; tutorials and instructions; co-design and open source resources; voting and crowdfunding systems; and, finally, the process based on observation, analysis, trial and error. On the other hand, the academic methodologies have not yet been sufficiently extended in practice. However, its evolution and development highlights the growing academic interest in prosumer users and their involvement in product design and manufacturing.

Regarding the main objective of the methods analyzed, we can see that most are focused on product design (14/15) and half of them on manufacturing (7/15), while only 3 are also focused on assembly. This is due to the widespread presence of digital tools before physical ones, a fact that can be verified in the methods analyzed in Table 2. In addition, despite the fact that in most cases prosumers are able to intervene in the phase of product design, only half of them also take care of its manufacture, since in the rest of the cases it is a third person who takes care of it.

About the differences between academic and real cases methods, we find that the objectives of the academic methods don't take into account the real interests of prosumers, who look for unique products made by themselves that respond to their wishes and needs, as has checked in the field study. Furthermore, academic methods only focus on product design, while the cases study shows that users are looking to get involved in assembly and manufacturing as well. This shows that what the user wants (field study) is not the same as what is offered (bibliographic analysis), giving rise to a niche in this field of research.

Given the need to include prosumers in the process of creating their own products by focusing on their true interests and taking into account not only design, but also assembly and manufacturing, finally two potential lines of future research are identified. Firstly, the development of a method specifically aimed at new non-specialized prosumer or maker users who are not yet familiar with the practice. And, secondly, a methodological evolution that includes new design tools that can enrich and facilitate user intervention, such as modular design.

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