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Assistive products development: a framework to respond to the value requirements from users and manufacturers points of view

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Abstract

This article presents an Assistive Product (AP) design model built in order to respond to the requirements of persons with disabilities. This target population is heterogeneous and their needs change over time, which is a great challenge in terms of customers' satisfaction, operational manufacturing performance, and financial results. The design model proposed is composed of design approach, containing the design principles that guide the process; and the design methodology (stages and their activities). This process was applied in a case study in the context of walking aids such as canes, crutches and walking frames was performed. This case brings insights about how to offer products variety to respond to different users in a suitable manufacturing environment.

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Keywords: Design model; assistive products; disabled people; volume and variety; lean development; mass customization; walking aids.

1. Introduction

Assistive Products (AP) comprises any device, equipment, instruments and software used by persons with disability in order to protect, support, train, measure or substitute body functions or structures. They are prescribed to prevent impairments and to avoid activity limitations or participation restrictions [1]. AP design is a great challenge because the population of disabled individuals is restricted to a small and heterogeneous group whose requirements change over time.

To develop a product valued by users, firms use strategies ranging from mass produced products to customized devices. However, this decision may consider trade-offs among users' value and effects in operational performance due to the increasing product variety to respond to diverse needs [2]. This is the key aspect of our problematic on AP design given that product features are decided on design, which affect users and manufacture. In this context, the literature points some AP rejection due to poor performance (bad value) and some AP with unaffordable prices justified by their production scale [3].

Therefore, this paper treats the conflict between customer's value and companies' operational performance. Firstly, that duality was analyzed through the literature about AP design approaches and studies about relations between product design and systems of fabrication. Next, a model of AP development was proposed and applied in a study case related to Walking Aids (WA) for personal mobility. Thus, this research brings insights about how offer products variety to respond to different users in a suitable fabrication environment. Moreover, it enables one to glimpse this model application in other AP.

2. Literature Review

Product development is defined as the conversion of a market opportunity and a set of assumptions about product technology into a product available for sale [4]. This occurs through a design process carried out through plans of action and methods that link and support the working phases [5]. Those supports are the models of design process, which are composed by some different levels of details. In the former layer one can found the design principles which are the process guidelines or the design philosophy (approach level).

In the level below we placed the methodology that contains the design steps (stages and activities) and the strategy about how to perform such steps. A design stage covers a large period of time, being based on the state of the product under design.

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In addition, a design activity is shorter and directly related to the design actions. The model design is influenced by the levels of complexity and innovation of the project. However, as least three stages are usually present: the problem definition, the solution search (conceptual design), and the solution selection in a detailed design [5]. Taking into account those elements, the next subsections present a research that aimed to outline an AP design model composition.

2.1. Assistive products design approaches

The literature has two categories of approaches o AP design: universal and specialized. In the first, designers try to make products to be usable to almost everyone, regardless of age, ability, etc. The results are standard products for mass production [6]. In contrast, in the specialized branch, products are designed for disabled people and produced in small batches. Thus, some AP are unaffordable without funding policies.

Universal approaches are quite similar since they emerge from the barrier-free movement. That initiative intended to remove environmental barriers to mobility and, progressively, its ideas were generalized, founding the universal design (UD). This process was busted by firms that became aware to the viability of elderly and disabled people as customers, and by globalized companies that provide products adjustable to different cultures and environments. A universal designed product must respect some principles such as equitable use and flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size and space for approach and use [6]. The specialized approaches include adaptable design, rehabilitation design, and assistive technology. The former performs modifications in regular products to make them usable for disabled people. The second focuses on the design of products for people with a new or temporary but severe disabilities. The last designs to medical conditions and the users are patients [7].

Although those categories are presented as separated sides, in the practice approaches may evolve. For instance, the approach Design for disability has evolved and became Inclusive Design. This approach assumes that every decision may exclude people, even in UD. Thus, the source of exclusion must be identified and removed. So, there is a dilemma: designers should design for the mainstream and make products more inclusive, or design for disabled people, making products mainstream-friendly. Fig. 1 permits the analysis of this issue dividing the population into three groups: people with severe disabilities (top of the pyramid), able-bodied people (bottom), and people with reduced strength and mobility (middle) [7].

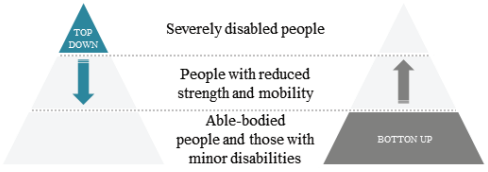

Fig. 1 - The user pyramid and design approaches [7]

The design of specialized products can be understood as a top-down strategy and products are designed for disabled people are gradually mainstreamed. On the other hand, the universal approaches target the mainstream with more inclusive products. The two approaches meet in the middle, where products and environments intermediate characteristics. In practice, the relevant question is not which is better, a universal or specialized views, but when each branch is most suitable. There are potential benefits of cooperation between both fields, and it is mostly not largely exploited [6], [7].

2.2. Product design and manufacturing systems

The product design processes shall be aware of their impacts on downstream business activities. In this sense, manufacturing deserves a special attention given that in most cases products are introduced on existing facilities [8]. Therefore, there is a parallel between manufacturing systems and products design.

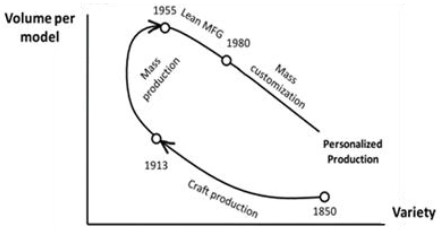

Fig. 2 - Volume-variety relationship of the manufacturing paradigms [9]

The Fig. 2 shows the volume-variety relations of paradigms of manufacturing. Design and fabrication of AP require volume and variety conciliation in order to respond to the disabled people needs with affordable costs. This indicates that lean manufacturing and mass customization are suitable models to AP context, being more detailed in the subsections below.

2.3. Lean manufacture and lean product design

Lean manufacturing organizes the activities to maximize value and eliminate waste through initiatives such value flow analysis, just-in-time etc. In this context the products are usually designed via lean product design, which is defined as cross-functional design practices governed by lean principles, some of them were used in this work [10], [11]:

- Customer value – it concentrates the process in the reaching of a deep customer understanding, centered in observation and immersion in the user's context;
- Front-loaded the process – it involves to map the design space, to explore solution alternatives and to narrow gradually the alternatives while the details are increased;
- Standardization – It involves to standardize design patterns, to standardize the design process making it predictable, and to balance the people skills to allow scheduling flexibility.

Taken into account this focus on standardization, the challenge is to reduce variation while preserving creativity. Thus, the value definition guides which standardize, which design from new, and direct the process of narrowing solutions. It concentrates the creativity to the added-value activities.