*Transdisciplinary Engineering Methods for Social Innovation of Industry 4.0*
*M. Peruzzini et al. (Eds.)*

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*doi:10.3233/978-1-61499-898-3-211*

# Human and User-Centered Design Product Development: A Literature Review and Reflections

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**Abstract.** New products are created for humans with the purpose of attending needs in the most varied contexts of their lives, therefore understanding these needs and meeting them through products that generate effectiveness, efficiency, satisfaction and good experiences is essential for business sustainability. Fields such as Ergonomics, Usability, User Experience (UX), Psychology and Anthropology are focused on studying these needs, and they have been applied to different types of products and services. Due to several updates in these areas and recent applications in digital products, there is an opportunity to update and structure the application of human-centered qualitative studies in physical Product Development Processes. The aim of this article is to identify main relevant studies about Human and User-Centered Product Development in the past 10 years and to reflect about new research opportunities. The research was carried out on Capes portal platform (Brazilian Government Scientific Database), which includes 532 databases, as well as through analysis of results, identifying fields of research, methodologies and themes such as the types of products studied. The results show interesting studies and gaps, proving that there are still opportunities to develop structured methods for Human and User-Centered Design for Physical Product Development, and that these developments can contribute for a better business sustainability.

**Keywords:** Product Development, User-Centered Design, Human-Centered Design.

## Introduction

There has been product development ever since human existence is known. Humans are naturally creative and have always created things to help them in their daily activities, communication, comfort or even for entertainment, beauty or personal and social reasons. The focus has always been the human, because products are created to be used by them and to fulfill their needs. Nowadays there are many different Product Development approaches, and despite industrialization and Science, a lot of methods and models have been and are being proposed for a better systematization, being that some of these approaches are focused on humans, and involve study areas such as Ergonomics, Human Factors, User-Centered Design (UCD), Human-Centered Design (HCD), Usability, and User Experience (UX).

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Due to technology advances and new digital products being created faster and faster, a lot of studies on Human and/or User-Centered Design areas are focusing and evolving on these types of products, and little advance is perceived on the development of physical products. However, physical products are still essential for human lives, and renewing knowledge on this field is very important.

On Product Development Sciences there are various approaches systematized into methods and models, which help industries to apply concepts, tools, as well as to have a better decision-making process and control during it. The focus of this article is to conduct a Systematic Literature Review (SLR) identifying existing methods and models on Product Development focused on Human and/or User as well as to analyze the fields and gaps that may generate further research opportunities.

## 1. Methodology

The research presented in this article has a qualitative approach, because it starts from realistic epistemologies, with the purpose of having a concrete action plan, and for the report on the research to be linked to the presupposition at each stage of the project as well as for it to be empirical [1]. The Systematic Literature Review (SLR) is an advanced, careful research that requires originality and contribution to create a solid knowledge base for the development of new research [2].

Based on Webster and Watson [2], Conforto *et al.* [3] and Levy and Ellis [4] who proposed three phases of a Systematic Literature Review: Input, Processing and Output, a 10 steps SLR roadmap was defined for this research, as shown in Figure 1 and detailed bellow.

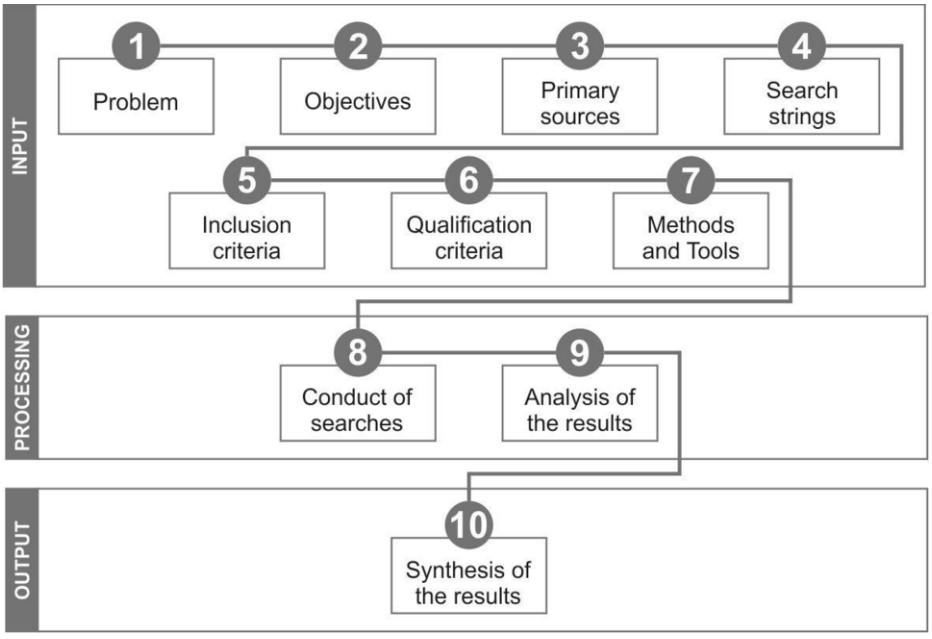


**Figure 1.** Systematic Literature Review roadmap. Source: The author.

- **Step 1 – Problem:** lack of knowledge on systematized and evolving studies about Physical Product Development Processes focused on Human and/or User.
- **Step 2 – Objectives:** to identify existing methods and models on Product Development focused on Human and/or User, to analyze them and identify further research opportunities.
- **Step 3 – Primary sources:** Macedo's [5] and Unruh's [6] dissertations, a few international standards related to User-Centered Design [7] [8], and the results of the survey of systematic reviews on product development [9] [10].
- **Step 4 – Search strings:** four groups of search terms were defined based on the primary sources and on the research objectives. Group 1: User, Usability, Human-centered and Human focus *; Group 2: Product development, Design and Engineer *; Group 3: Method, Model, Tool and Technique; Group 4: Ergonomic and Human factor (the "*" allows the searcher to consider several terms for the respective words). Groups 1 and 4 were crossed with Group 2, and Group 1 was also crossed with Group 3. The search of these crossed terms was carried out in the Periodicals Portal of Capes, a Brazilian Portal with access to 532 databases. Only articles in English of the previous 20 years and peer reviewed journals were taken into consideration, and the following topics were included: User-Centered Design, Ergonomics, Product Development, End Users, Usability, Design, Design Engineering and Engineering.
- **Step 5 – Inclusion criteria:** the articles selected should mention in the title or abstract the application of User-Centered Design methods, techniques, frameworks or similar in the product development process, for physical or digital products, but more likely physical products. Articles with a focus on digital products were consulted only if they considered the whole process including different techniques that could also be applied on physical products. Articles related to education, ontology, cartography, energy efficiency, videos or medicine, or articles with only one specific technique or tool were not considered.
- **Step 6 – Qualification criteria:** after the selection, the articles were qualified according to 3 groups: 1) Product type (Physical or Digital); 2) Proposal of the article (Complete PDP method/model, Partial PDP method/model, Specific method, tool or technique, Framework/Approach/Guidelines/Requirements, Case study only, Concept/Discussion); 3) Field of Science (Research only, Human-Centered Design (HCD), User-Centered Design (UCD), Usability, User Experience (UX), Human Experience (HX), Ergonomics/Human Factors, Emotion/Affection, Participatory Design, Quality , Kansei, Universal Design).
- **Step 7 – Methods and tools:** the analysis was performed in the Excel software, inputting all data in tables for analysis.
- **Step 8 – Conduct of searches:** the search led to 1989 results, of which 346 articles were pre-selected. Then, through a deeper analysis with the application of the qualification criteria, this number was reduced to 134 articles.
- **Step 9 – Analysis of the results:** after organizing the articles in the qualification criteria, they were analyzed. The analysis is presented in item 2 (Results).

- **Step 10 – Synthesis of results:** after the analysis of the results, they were synthesized in item 3 (Conclusion).

The research questions which will be answered in the analysis of results are: I) Which are the existing Product Development Process methods, models or frameworks focused on human or user? II) Do they present a whole and detailed process? III) Which fields are considered the most in the articles? IV) Do the methods, models or frameworks include Human/User-Centered Design techniques? V) Which are the gaps on the selected articles?

## 2. Results

The search carried out as previously described led to 1989 results, the titles of these results were first analyzed for a pre-selection, from this analysis 346 articles were selected and later they were analyzed more deeply for a final selection of 134 relevant articles which will be analyzed in this item, taking into consideration the years of publications, types of products focused on the publications, types of proposals, fields of Science and some other identified characteristics.

Related to years of publications, as shown in Figure 2, most of the relevant publications are from 2012, being that until this year there is a balanced growth which shows a decrease after 2012 but seems to remain balanced. The year of 2017 shows few results because the research was carried out during 2017, thus, most articles of this year will start to be available in 2018 only.

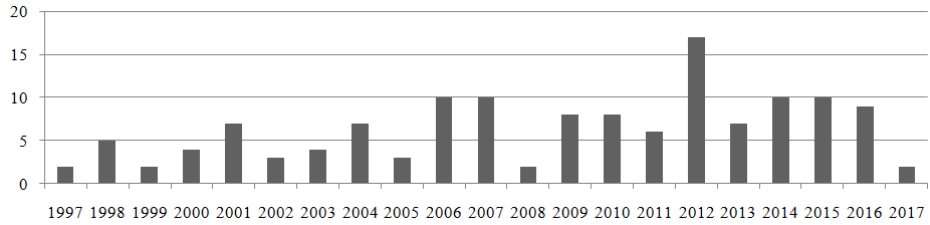


**Figure 2.** Years of publications of the selected articles. Source: The author.

Figures 3, 4 and 5 refer to the qualification criteria, through which each article has been qualified in the following categories: Product type, Proposal of the article and Field of Science.

The product types identified as being the focus of the articles (Figure 3) were well divided between physical, digital and both (in cases in which a physical product has also a digital interaction). Most of the articles selected are about physical products because this is the focus of this research, however, since there are a lot of studies focusing on digital products, this is what most of the results were about, yet, some of them were still considered because they are related to Human or User-Centered Product development, and most of the concepts, as well as some of the techniques and methods can also be applied to physical products. This occurs since terms such as Usability and User Experience have come from digital fields, while terms such as Ergonomics and Human Factors have their origin in the research on physical products. Also, due to digital technology advances in the past years, a lot of effort has been dedicated to this area.

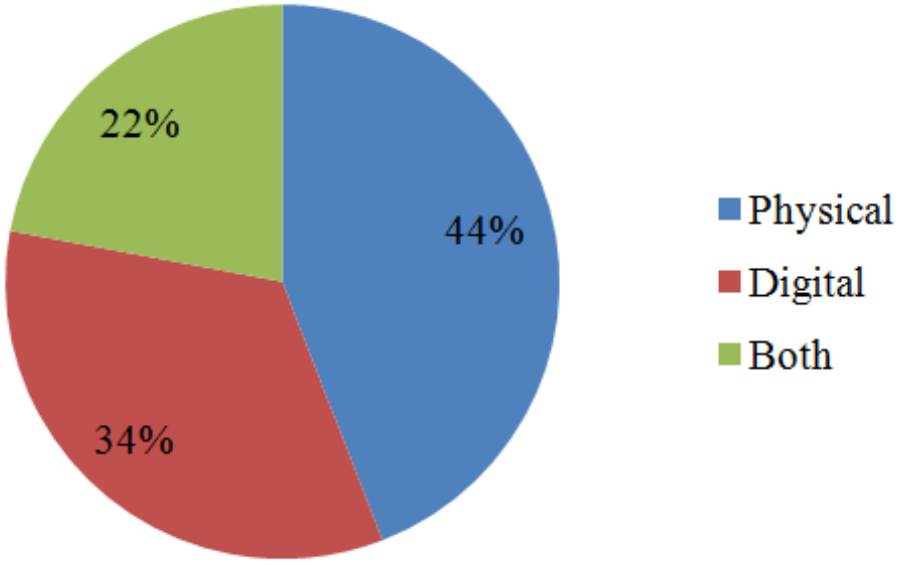


**Figure 3.** Types of products focused on in the selected articles. Source: The author.

Figure 4 shows the proposals of the Articles, whether they proposed a complete PDP method or model (considering the whole process and all steps), a partial PDP method or model (considering only one or a few stages of a PDP), a specific tool, method or technique (not necessarily inserted in a whole PDP), a framework, approach, guidelines or requirements that could be relevant for a PDP. Only one case study considering the PDP, or a concept or discussion of the insertion of Human/User-Centered approaches a PDP. This data shows that most of the results (51%) present case studies without a proposal of a structured method/model but proves also the importance of the approach. Following are articles related to concepts and discussions concerning the theme (22%), showing that this field is important and that there is a lot to be discussed, structured and applied, for this reason the next item is related to frameworks, approaches, guidelines and requirements (11%) which is a first step to the subsequent, complete PDP method/model (10%), which have been proposed but still need to be developed. Few results are about partial PDP models and specific methods, tools or techniques because they are not the aim of this study, so some of these were selected because they seemed to be relevant and that they could contribute for the main purpose.

The results of the search presented various different approaches and situations of applications of Human/User-Centered concepts, many of them were about the moment of choice and consumption of products instead of the product development process, and it is not clear what should be the focus of this field of Science, because sometimes it is applied for a moment of consumption, others for a moment of usage, and others for services and maintenance. The fields related to them are also not clear, because some journals and studies are from engineering, design, marketing or even medicine. So, it is not a specific Science for one area, but it involves different moments in Product

Development, different disciplines and applications for a same purpose: making products better for the needs of people.

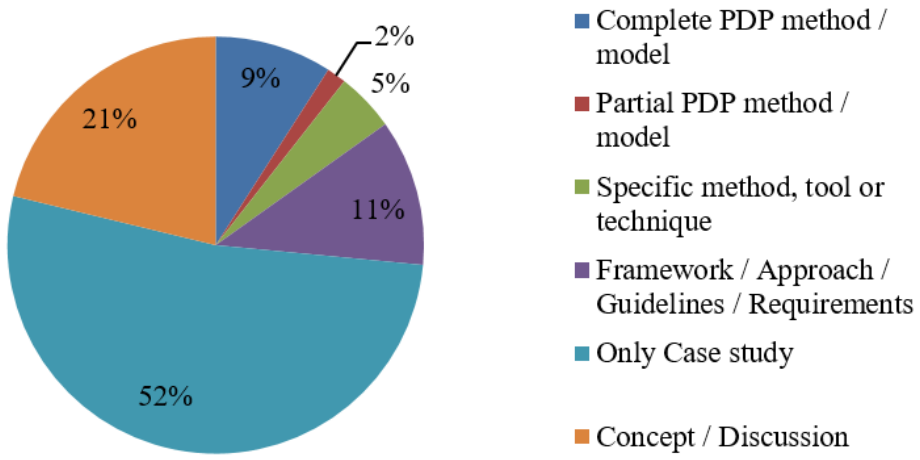


**Figure 4.** Proposal of the articles selected. Source: The author.

Figure 5 presents the fields approached in the articles. It is interesting to note that the search considered terms related to both users and humans, but most of the results have a user focus, always naming the human as "users", and what humans do as "use products". The same happens on fields such as marketing, in which humans are called consumers, because of what they do, consume. In smaller numbers, terms related to human appear mostly in medical articles, probably due to the profile of the profession, which considers humans as who they are, instead of as what they do. Thus, most results applied the terms: UCD – User-Centered Design (35%), Ergonomics/Human Factors (22%) and Usability (18%). Also, other terms such as HCD – Human-Centered Design, Participatory Design, Quality, Universal Design (which considers people with disabilities in some sense), Kansei (Mathematical Methods for People Evaluation), and Research (refers to research in general and not specifically related to any of the areas mentioned above) appeared less but are related fields.

An important finding noticed in this research is that there are so many terms and fields of Science talking about developing products with a focus on humans/users that there are a lot of common but also a lot of different kinds of techniques and methods, and each research applies it in specific ways and focuses, but there is a lack of clarity regarding which techniques or methods should be used in each moment, even articles that present a complete PDP method have not been structured. There is a great opportunity to analyze methods, models, techniques, tools and to clarify in which situations and for what purpose each of them can be applied, because this kind of information could help industries to facilitate processes through the application of this approach and through a more efficient decision-making process in terms of which technique to use. Moreover, the subjects involved could also have a clearer understanding of their roles.

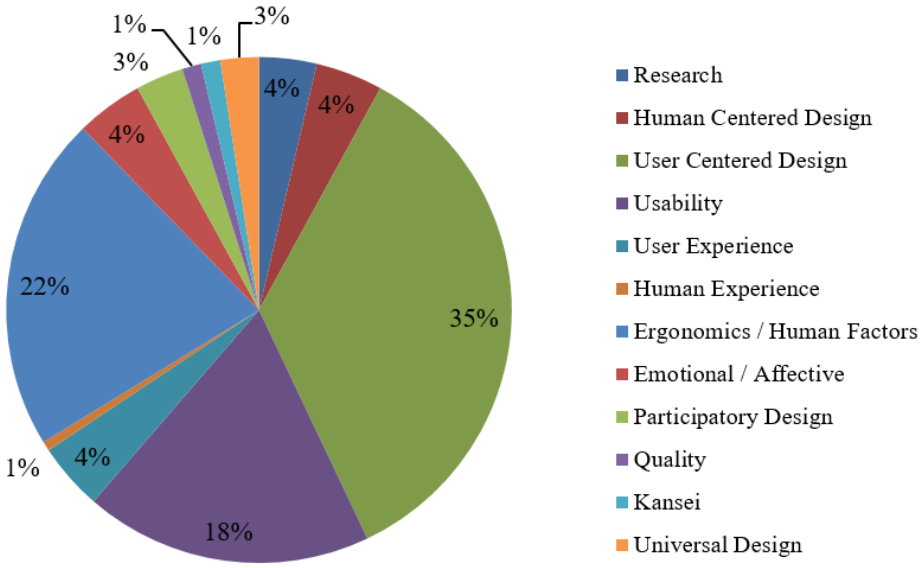


**Figure 5.** Fields of Science of the artciels selected. Source: The author.

After these analysis on years of publication, types of products, proposal of the articles and fields of Science, nine of the articles selected were identified as being directly connected to the aim of this article, that is, a proposal of a complete PDP method, model or framework considering Human or User-Centered Design and the possibility to apply them on physical products, as presented in table 1, which also shows an overview of the main contributions and limitations of each of them.

**Table 1.** Content Analysis.

| Title | Authors | Year | Contributions | Limitations |
|---|---|---|---|---|
| A user-based design process for Web sites [11] | E.G. Abels, M.D. White, K. Hahn | 1998 | A structured method with details of each PDP phase. | Focused on digital interfaces. |
| Customer, consumer and user involvement in product development: A framework and a review of selected methods [12] | M.A. Kaulio | 1998 | Presents some UCD methods and in which moment of a PDP they can be applied. | Considers only seven UCD methods and lack of detail of the application on an entire process. |
| A field study of the Wheel—a usability engineering process model [13] | J.W. Helms, J.D. Arthur, D. Hix, H.R. Hartson. | 2006 | Nonlinear model, meaning it is flexible for different projects, application of techniques, resources, and possibility of a dynamic decision-making process. | Focused on digital systems and does not quote any UCD techniques, only considerations regarding it. |
| Usability in Product Development: a conceptual framework [14] | J.I. van Kuijk, H.H.C.M. Christiaans, H. Kanis, D.J. van Eijk. | 2007 | Framework considering fields involved and actors, presenting each phase of the PDP. | Lack of phases detailing, lack of information about UCD techniques and decision criteria for each phase. |

| | | | | |
|---|---|---|---|---|
| A Method for User Centering Systematic Product Development Aimed at Industrial Design Students [15] | D.A. Coelho. | 2010 | Structured PDP detailing each phase and outputs, also has a structured task clarification of the design process. | It is focused on the conceptual phase of a PDP and does not quote any UCD techniques, only considerations about it. |
| Creativity in Ergonomic Design: A Supplemental Value-Adding Source for Product and Service Development [16] | L. Zeng, R. Proctor, G. Salvendy | 2010 | Presents a model based on Usability and Ergonomics for a creative PDP. | Does not quote any UCD techniques, only considerations about it. |
| Implementation of ergonomic aspects throughout the engineering design process: Human-Artefact-Context analysis [17] | J. Hoyos-Ruiz, J. Martínez-Cadavid, G. Osorio-Gómez, R. Mejía-Gutiérrez | 2015 | A detailing PDP method for Ergonomics, applying different techniques. | Focused only on ergonomics (physical, safety and comfort aspects). |
| A systematic user-centered framework for engineering product design in small- and medium-sized enterprises (SMEs) [18] | F. Gherardini, C. Renzi, F. Leali | 2016 | Very structured method with decision-making support and details about each phase. | Focused on digital systems, and small techniques for the application of physical products. |

All of these articles show the need for a structured model for HCD or UCD application on PDP, but each of them presents a solution for a small part of this need, and the other articles analyzed do not present a complete PDP structure that could be applied to different situations, rather they present important case studies or discussions to be applied to it.

Some highlights on the contributions of these articles are: Kujik *et al.* [14] argues that in literature there was not a coherent proposal for Usability practice on PDP, for this reason they proposed a framework for it, considering all actors involved in the process, but it is not clear which technique should be used on each phase or which criteria makes a product ready for the next phase; Helms *et al.* [13] contributes with a very dynamic and flexible model which opens a lot of possibilities and is very coherent with a UCD process; Kaulio [12] presents UCD methods and in which moment they can be applied, which is an important structure for its application on a PDP, but there are a lot more methods and techniques to be considered, and it does not detail the process of application and the output of each of them; Hoyos-Ruiz *et al.* [17] presented a very structured method, detailing each step, which is certainly a great reference for the application of UCD on PDP, but it is focused only on ergonomics, and it could have added UCD, Usability and other concepts; and Gherardini *et al.* [18] presented a method that was very well structured, detailing each step and also presenting equations for decision-making and a more efficient process, but it is focused on digital systems, and few of the techniques can be applied on physical products.

Each of these authors contributes considerably in this field and presented structured methods with specific important aspects. There still is a lot to be studied and evolved, because as perceived through the other articles selected, there are many techniques and methods which could be applied on a same structured PDP according to the resources and needs of each phase and to each specific product being developed, specially to physical products, about which there are less studies.

## 3. Conclusion

The research presented in this article has explored preliminarily a literature review and reflections about human and User-Centered Design product development. According to the research objectives, it was possible to identify and analyze researches being handled in the field in the previous 20 years. It was possible to observe that the growth of studies in the area occurred starting in 2006 and was more expressive in 2012, that there is a lot of study effort focused on digital products, which reflects the evolution of technology in this area in recent years, and its need of adaptation to people who use it, but that there are few structured methods or models for its application. It is also possible to notice that there are several cases in which physical and digital products complement each other, because there are several physical products with digital interactions, but few studies link both of them clearly.

It was possible to observe as well that some articles use the term "human" and others "user", while other fields nominate people as "consumers" or "costumers", this is because the focus is usually on what people do instead of who they are. It is a psychosocial important discussion to be considered during the moment the world is going through, of rethinking social models, economics, health and environmental situations.

Also, it was possible to identify that most articles do not present Human/User-Centered Design techniques during the process, or that part of them present only a few of the existing ones, only some of the articles present which kind of Human/User focused research can be handled in each PDP phase and even less present a decision-making method to decide which technique to use or how to decide if the product has really achieved the Human/User focus objective.

Thus, it was possible to identify some further research opportunities, which are: to study product and digital mixed products such as Internet of Things Products focused on Human/User-Centered Design; to discuss the terms "human" *vs*. "user"; and to develop studies and structured methods that contemplate the application of Human/User-Centered Design techniques in Product Development Processes. Although the research questions had relevant results, for a better accuracy and deepening on the answers, there is a need for a deeper study on the state of art of the selected articles.

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