

A survey of methods for product design and development with regards to ergoecological principles

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Abstract. This paper presents the first part of the analysis of a literature review conducted to build an inventory of methods/models for design, development and innovation of products that are focused on both –the human factor (user) and the environmental factor (sustainability). Four databases were selected and reviewed using criteria of robustness, coverage and relevant thematic. About 1900 items were found by applying 56 search equations. Over 850 articles were classified to identify those combining simultaneously the application of Human Factors and Environmental Factors and the analysis is driven towards recognizing the state of the art in terms of each of the principles and postulates of Ergoecology.

Keywords. Sustainability, eco-efficiency, eco-productivity, product-design methods

1. Introduction

The work presented in this paper is part of a collaborative research project looking for the development of ergoecology as a framework for the design and development of innovative products and services. Ergoecology is a multidiscipline that studies human beings and their relationships with the environment by analysing their activities to establish the impact of this relationship (García-Acosta et al, 2012a). It proposes a symmetric view of ergonomics and ecological aspects.

To explore what methods/models for design, development and innovation of products and services that are focused on both –the human factor (user) and the environmental factor (sustainability)– it was proposed to conduct a literature review in books and through specialized articles published on scientific journals, focusing on those methods/models structured within direct relationship to environmental and ergonomic aspects to compile and build an inventory of them. As literature review –as mention above– was conducted combining different research equations that included HFE, environmental, and design variables. This paper presents results of the first analysis, focusing on general trends of publications relating HFE, ecological, and design aspects.

2. Methods

The basis for the review was the Ergoecological Fundamentals, which include: principles (anthropocentric approach, sustainability and systemic approach), postulates

(eco-productivity, eco-efficiency (García et al 2012b) and eco-effectiveness (Thatcher et al 2013). A matrix relating these concepts with notions (macroconcepts) regarding design, product development, innovation, sustainability, ecology, and ergonomics was built, in order to identify the key words to be used for building the search equations. Identified trends in HFE for consumer product design (García et al, 2011; Puentes-Lagos et al, 2013) were also taken into account.

Regarding research universe, 56 databases that could be accessed by the participant universities of the project (Pontificia Universidad Javeriana, Universidad Nacional de Colombia and the Universitat Politècnica de Catalunya) were considered. From this list, 13 databases were selected using the criteria of robustness and coverage. Finally, based on an academic articles classification made by the Administrative Department of Science, Technology and Innovation (Colciencias), four databases were chosen: Scopus/IEEE, Compendex, Sciencedirect, and Proquest.

Using the macroconcepts versus Ergoecological Fundamentals matrix, several search equations were constructed. In the first search query equations were set up with Booleans. The first five equations included three terms; two as constants and one variable. The last three equations were defined only using the concepts framed by sustainability: Eco-efficiency, eco-productivity and eco-effectiveness. Search equations were established to initiate the collection of documents. As mentioned above, the three terms used were: as constants, the macroconcepts of human approach (design and ergonomics) and as variable the macroconcepts of environmental focus (sustainability, eco-productivity, eco-efficiency, eco-effectiveness, ecology and sustainable development). As a result were obtained 8 equations.

Table 1: Equations for the first search.

Design And Ergonomics And Sustainability
Design And Ergonomics And Eco-Productivity
Design And Ergonomics And Eco-Efficiency Or Eco-Effectiveness
Design And Ergonomics And Ecology
Design And Ergonomics And Sustainable Development
Eco-Productivity
Eco-Efficiency
Eco-Effectiveness

To perform the second search query the only equations constant used was the term “design method”. Term model did not provide differentiation in the search and was therefore omitted from the equation. Variables were provided by concepts associated to the Human Factor with six variables: 1) User Centered Design; 2) Usability; 3) Participatory Design; 4) Universal Design; 5) Emotional Design and 6) Cross-Cultural Design. And concepts associated to the Environment Factor with eight variables: 1) Sustainable Design Or Eco-Design; 2) Environmentally Friendly; 3) Design For Environment; 4) Restorative Design Or Design For Recovery; 5) Design For Reuse; 6) Cleaner Production Or Design For Reducing Emissions; 7) Design For Disassembly Or Design For Waste Minimization and 8) Vernacular Design (Indigenous). Hence, 48 equations were obtained as shown in Figure 1.



Figure 1: Constant and variables for equations construction of second search.

About 1900 documents were compiled at the first moment. Given the amount of documents returned, it was required to implement new debugging criteria. That for bibliographic managers (Refworks and Endnote) were used to eliminate those repeated in different databases and publication types (lectures or articles), reducing the total near to 850 documents to analysed.

3. Results

3.1 Findings of the first search (Macroconcepts + Postulates)

Aforementioned, the first search included the use of eight equations. Here, approximate 65% of the total of documents were found and can be observed the following tendencies.

3.1.1 Amount of articles per database

The most robust database in relationship to the volume of articles associated to human factors and environmental factors was Scopus/IEEE. About 68% of the total of documents was found in this database. The second database with more associated documents was Compendex over 16% of the total. The other two databases sum together around 15%.

3.1.2 Amount of articles per equation

Most of the articles found were associated to the equation 7 (design+ergonomics+eco-efficiency), around 38% of the total of documents found using the eight equations. Equation 1 (design+ergonomics+sustainability) had the second place, around 35% of the total of documents. Equations 4, 5 and 6 including the variables ecology, sustainable development and eco-productivity by itself sum, together, over 21% of the total of documents. The last group of documents was found with the equations 2, 3 and 8 (including the variables eco-productivity, eco-efficiency, eco-effectiveness) cumulating less than 5% of the documents.

3.1.3 Amount of articles per year

The first search included the years 1989 to 2013. Between 1989 and 1996 no more than four articles per year were published and were not accessible. From 1997 to 1999 the

number of publications per year did not reach 10 articles. From 2000 to 2004, the number of publications incremented from 10 to 20. From 2005 to 2011 the number of articles per year continued growing, reaching almost 40 publications per year. 2012 was an atypical year reaching around 60 articles in that year duplicating the media of past years.

3.1.4 Journals with the most of published articles

The total search included the years from 1989 to 2013. Only articles published in the last three years were used. Journals that published two or more articles in the last three years were selected. The result was 371 documents in 38 different journals. While 16 journals (42%) published only two articles (9%), three journals i.e. Applied Ergonomics, Journal of Cleaner Production and Ergonomics (9% of the journals) published between 32 and 51 articles, what represents 33% of the total of articles in the same three years. Other journals that published several articles (between 15 and 25) were International Journal of Industrial Ergonomics, International Journal of Life Cycle Assessment, Proceedings of the Human Factors and Ergonomics Society Annual Meeting, and Work. Considering the five journals with the greatest number of publications, four are focused on themes related to HFE while just one is oriented to environmental factors. Also, it was found that more than 60% of the journals focus on environmental factors and around 19% were interested in HFE. Lastly, almost 19% of the journals deal with themes related to production and design.

3.2 Findings of the second search (Design Models+HF+EF)

The second search was made by the use of 48 equations already explained (see figure 1). The results represents near to 35% of the total of collected documents.

3.2.1 Amount of articles per database

Similar to search 1, the most robust database was Scopus/IEEE with over 47% of all found documents. Also, the second database with more number of documents was Compendex (around 20% of the documents), followed by Science Direct (about 19%) and Proquest (over 13%).

3.2.2 Amount of articles per equation

Equations of the second search were grouped thinking six variables of Human Factors (HF) as observed in figure 1. Considering this perspective, it was found that all eight variables regarding environmental factor had a greater association with HF variable 4: “universal design or design for all” with more than 50% of the founded documents. The second place was for HF variable 5: “emotional design or experience design” with near 27%. The HF variables that followed were: “usability” (10%), “user centered design” (7%), “participatory design” (4%) and “cross-cultural design” (1%).

3.2.3 Amount of articles per year

The second search included the years 1991 to 2013. Between 1991 and 1996 no more than four articles per year were published and were not accessible. Also From 1997 to 1999 the number of publications per year did not reach 10 articles. However, from 2000 to 2004 the number of articles ups and downs from 3 to 17. From 2005 to 2009 the number of articles remained around to 20. Here were observed two atypical years: 2010 and 2012 with almost 30 articles.

3.2.4 Journals with the most published articles

In the same way of the first search, for a more refined analysis, publications of the last

three years were selected, including all journals that published two or more related articles per year. 123 articles distributed in 17 journals were found. Here, 13 journals that published between two and three articles represent 75% of the total of journals. These publications added, are equivalent to around 20% of the total of articles. –International Journal of Life Cycle Assessment, Journal of Industrial Ecology and Materials & Design– have four publications each (around 10% of the total of articles). Lastly, the Journal of Cleaner Production represents less than 1% of the total of journals but it has more than 30 articles (25% of the total of publications).

4. Discussion and Conclusion

Although Scopus/IEEE was the most relevant database regarding number of documents found (first search), it is not possible to affirm that the work more related to the Ergoecological fundamentals can be found on it.

Regarding the group of eight equations of the first search, it is possible to conclude that the scientific community has concentrated its work on themes associated with the variables sustainability and eco-efficiency, together representing more than 70% of the founded documents. Additionally, the equation associating design + ergonomics + eco-productivity was the one registering fewer documents, opposite to the equation that included just the postulate eco-productivity.

During the last 18 years, a constant growth of number of publications associating HF variables and environmental variables was found (first search). This shows the interest that the scientific community is given to the connection of these themes, especially from 2006.

Findings of the first search suggest that there are more journals dealing just with environmental factors, while journals oriented to HFE tend to include more environmental topics.

Considering the second search, no particular growing trend could be observed. However, since 2005 one cannot find less than 20 articles dealing with methods for design and development of product/services. With regard to the second search (concentrated on methods), three of the four journals with the most published articles focus on HFE. This suggests that the HFE scientific community is the one that is working for linking human aspects with themes associated to sustainability. Considering that the second search is more specific for the equation construction, fewer documents in total and per equation were found. Also, the distribution of the quantity of documents among the four databases was more homogeneous.

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