

# The State of Research in Circular Design in Portugal and Worldwide: A Bibliometric Analysis

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The affirmation of “Circular Design”, as an area of the scientific domain of Design, in association with the Circular Economy, constitutes a relevant reason for research in Design, through interdisciplinary articulation with areas such as Materials Science, Chemistry, and Environmental Sciences.

For a better perception of the pertinence of the domain, a quantitative and qualitative analysis was carried out, to ascertain the national and international state of research in Circular Design and forecast the future of research in this field. The data were obtained using the Web Of Science and RCAAP - Open Access Scientific Repository of Portugal platform and subdivided into categories, to be able to study the evolution of research from various perspectives, ending in a robust comparative analysis, based on the triangulation of information.

For the quantitative analysis, we used data from submitted articles indexed on the Web Of Science (using search by topic, keywords, and abstract) and from articles indexed in RCAAP (through a search by subject, derived from the search engine limitation).

A research-based on the subject (RCAAP) was used for qualitative analysis to understand the doctoral theses and MSc dissertations produced in Portugal. From the analysis and treatment of the data, it was concluded that the Netherlands has greater maturity in research, in several of the variables studied. Portugal presents a residual representation in the documents indexed in the Web of Science, contrary to the RCAAP, Sustainable Design presents a growing tendency in the application of the concepts of Circular Design (although indirectly). The growth of research in the area is exponential (according to the Web of Science, 65% of scientific production has been made in the last 5 years), which reveals the opportunity and relevance of research in Design applied to the Circular Economy. At a qualitative level, the investigations carried out in Portugal, although few, demonstrate robustness in the application of concepts, both at a project and methodological level, confirming and demonstrating the opportunity of the fundamental research carried out in this area, with at least two PhD theses and two MSc dissertations degrees focused on Circular Design. The application of an investigation through Design constitutes the Project as a research model validated by peers.

#### Keywords

Circular Design;  
Design Research;  
Design Analysis;  
Design Opportunities.

## Introduction and contextualization

The debate about sustainability through design is recurrent. Considering the need to develop methods of quantitative and qualitative evaluation related to the production of science in the area of Circular Design, the Web of Science (WoS) was used to evaluate the research worldwide (indexed in its database).

In the Portuguese case, the RCAAP (Portuguese Open Access Scientific Repository) was used, collecting data from master's dissertations and doctoral theses, adopting as "subject", the research selection/segmentation variable. The objective is to collect the state of the art, establish terms associated with project practices in design and identify presumable new contributions to the enhancement of the discipline. For global analysis, WoS was used due to the ease of investigation, scope of the database and scientific quality of the indexed publications. Master's dissertations and doctoral theses were selected in the RCAAP (which, as they constitute the database, are already duly validated, following the legislation for obtaining approval), and constitute emerging focuses of scientific production in higher education institutions. Portuguese. With a view to etymological clarification, a literature review was used, establishing the concepts and definitions to be addressed in this document and the research model.

## **Etymological Clarification**

The term circular economy refers to economists David Pearce and Kerry Turner (1990), later stabilized by Kenneth Boulding. "(...) which presents the idea of a closed economy, where resources are limited, and tools must be developed to continually renew their resources." (Pinho et al., 2020, p. 36). The expansion and dissemination of the concept are attributed to the Ellen MacArthur Foundation, through the development of relevant projects and analyses in the various sectors of activity, serving as a basis for the implementation of strategies. The Ellen MacArthur Foundation defines the Circular Economy as an alternative that seeks to redefine the notion of growth, with a focus on social benefits. This implies decoupling economic activity from the consumption of finite resources and eliminating waste from the system. It is supported by the transition to renewable energy sources. The circular model builds economic, natural and social capital (Circular Economy Introduction - Overview, n.d.). The design has used circular economy strategies as a justification to design new products within the economic cycle of waste recovery, its mitigation and circularity. The application of circular economy concepts by Design is called Circular Design. The Ellen MacArthur Foundation defines Circular Design as the practice of applying circular economy principles in design. It is based on systems thinking to mitigate the interconnected problems faced today. Circular Design is based on the creation of a regenerative and resilient future, where products, services and systems are designed with the big picture in mind, emphasizing the reuse of materials and waste and their future insertion in the value cycle.

The definition of Circular Design strategies starts with the notion that Design concerns the entire economic circle of change. The ability to continue to add sustainable value is the crux. Therefore, the extra requirements for a certain new product concern a certain robustness and affordability. This must be added to all others, in logistics, brand identity, energy consumption and other factors involved in the product (Bakker et al., 2015, p. 97).

## Sustainable Design and Circular Design

The authors of *Products That Last* (2015) argue that Sustainable Design focuses mostly on the material issue, based on solving simple questions. Despite the additional concern regarding energy consumption, modularity and the reduction of material heterogeneity, the analysis of the life cycle of the products and the entire system that composes it (design, production, distribution, purchase, use, disposal) is not taken into account. and repair). This thinking suffers from a serious gap, as a result of little concern in extending the life cycle of products, with no due emphasis on the design and production of artefacts with a view to circularity. The extension of the life cycle, and the return to the circular process, comes several times from a question of form, that is, through the design, artefacts are designed with greater durability and that incite a lesser propensity to discard, both in material and through the creation of an emotional, affective and aesthetic relationship with the user.

## Literature

In addition to the authors directly linked to the aforementioned concepts, it is important to note other relevant contributions, such as Victor Papanek (2019), *Design for the Real World*, one of the first designers to have an effective concern and development of knowledge linked to the areas of sustainability in design. ; Pauline Madge (1997) in *Ecological Design: A New Critique* which stabilizes the first differences in the various prisms of sustainability-oriented design; Michael Braungart and William McDonough (2002) authors of cradle-to-cradle thinking; Alastair Fuad-Luke (2009) highlighting the activist position of design in social innovation; Victor Margolin (2015), *The Good City: Design for Sustainability*; Stuart Walker (Walker, 1995, 2006, 2017) as one of the most prominent authors of design for sustainability; Stahel (2019) who presents, in a holistic view, a guide for the application of the circular economy; and more recently Jane Penty (2020), which systematizes and consolidates thinking and strategies for sustainable product development through design.

## Data Analysis and Collection Methods Data

Were collected worldwide on the WoS platform, using three research variables: topic; keywords; Summary. The decision made to resort to 3 analysis variables (ensuring triangulation and redundancy of information) in the specific case of WoS is justified due to the size of the platform data, allowing their intersection, and obtaining robust data, which directly addresses the subject. for research, encouraging concrete analysis. In the Portuguese case, the RCAAP was used, inserting three subjects relevant to the research area into the search engine; 'circular economy', 'circular design' and 'sustainable development. The results were filtered to obtain data related to master's dissertations and doctoral theses in which the subject was directly related to the mentioned words. Contrary to what happened with WoS, as the RCAAP data cover a small sample, the search was expanded into 2 terms close to a circular design, so that in the analysis it was possible to cross the information ensuring, in a different way from the previous one, the triangulation of the information. After selecting the data, they were entered into a spreadsheet and the relevant information for the study was processed, namely: title, year, higher education institution, area of study, country, type of document, keywords and authors. We proceeded to the study and analysis of variables, at a qualitative and quantitative level, from the representative universe of data. The study was divided between doctoral theses and master's dissertations (in the Portuguese case) and scientific publications indexed in WoS (Articles, Proceedings, Essays, and Review Articles...).

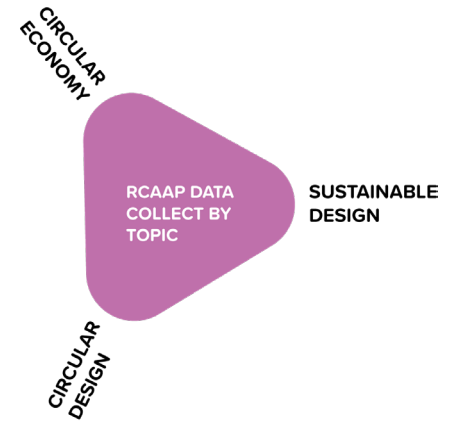


Fig. 1

Method of RCAAP Data Collection

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## Data analysis Web Of Science

The three search variables used in the WoS search engine showed different sample dimensions: topic, 211 information entries; summary, 161 entries; keywords, 51 entries. In the first analysis, it is understood that the use of the keyword 'circular design' still needs to be used. Keywords are usually used as a way of investigating specific terms, which shows that only 51 documents effectively focus on the study of circular design, in the field of fundamental and/or applied research. In the same way, it is evident in the 3 variables, TU Delft is one of the most representative institutions of higher education in the study of the concept, presenting itself in the 3 institutions with more scientific communications in the field (in the three study variables), which reflects the scientific interest of the Netherlands in the study of Circular Design. Despite the indicators, above all at a chronological level, there has been a significant increase in research on the subject in the last

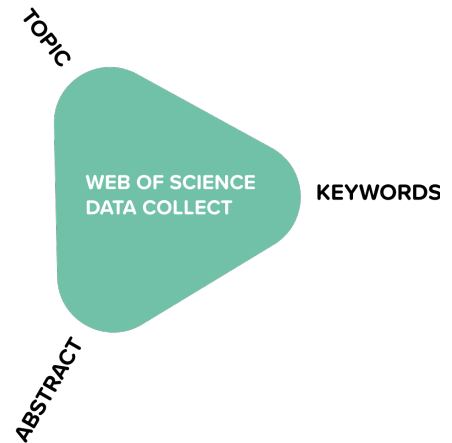


Fig. 2

Method of Web of Science Data Collection

10 years, although the design does not have a prominent place as a leading area in circular design research. Engineering (Topic - 36%; Keywords - 20%; Abstract - 37%), Technology (Topic - 32%; Keywords - 49%; Abstract - 37%) and Environmental Sciences (Topic - 29%; Keywords - 20%; Abstract - 26.7%), continue to lead the development of science in this area with an evident distance compared to the rest. Regarding the authors, Conny Bakker (TUDelft), Ruud Balkenende (TUDelft), Fiona Charney (University of Exeter Business School), Cini Varghese (ICAR - Indian Agricultural Statistics Research Institute) and Georges Romme (Eindhoven University of Technology) identify themselves as prominent authors with a greater number of publications, despite the huge diffusion presents in the data. The Netherlands, once again (and crossing the data of higher education institutions) proves to be the country with the greatest development of research in a circular design, although relatively dependent on a technological vision. In the Portuguese case, WoS shows scientific publications indexed in the topic (6 indexes) and abstract (6 indexes) variables. The percentage representations of Portuguese publications are 2.8% and 3.7%, respectively, compared to the Netherlands with 5 to 6 times more publications, 15.6% and 16.1%.

## RCAAP

The doctoral theses, totalling 14 and considering their area of study, present Design as a leader in the subjects referenced, presenting a percentage of mastery over the others, with about 29% (4 theses), followed by Electromechanical Engineering with 2 theses, and the remaining areas with only one. In the case of master's dissertations, although the design presents a high number of dissertations defended in the mentioned subjects (214), it is in second place with 53 dissertations (25%). The scientific area of Design, in both cases, stands out as one of the areas with the greatest concern in the development of solutions with a view to the environment and waste management, which validates and demonstrates the importance of research in this field, opening opportunities for the development of unprecedented content in the investigation, deepening and expansion of the discipline. Keywords are a study variable of great importance as they allow us to understand trends in research and the application of concepts. We then selected, from the various theses and dissertations presented, those that used the concepts 'circular economy', 'circular design', and 'sustainable design' in their keywords.

In both types of documents (master's dissertations and doctoral theses) we observed that the keyword 'circular economy' (148 out of 258 - 57%) prevails with a significant difference from the others, with the same tendency being verified when it comes to of the English term 'circular economy' (81 out of 258 - 31.3%).

One of the explanations for the greater incidence of the expression circular economy derives from the transdisciplinary theme, allowing several disciplines to approach the model, and to investigate within the premises of circularity, contrary to the other concepts that are governed exclusively by scientific areas linked to design or development of project. It is also understood that the words 'circular design' (4 out of 258 - 1.5%) and 'circular design' (2 out of 258 - 0.7%) are mentioned a few times, and always in investigations in design. The little application of this concept constitutes an opportunity for investigation and deepening of the concept.

### **Comparative Analysis**

Comparing the data obtained in the RCAAP and the WoS, the low incidence of the term circular design in the RCAAP database, with only 6 keywords mentioned (4 in Portuguese, 2 in English) in Master's dissertations. The RCAAP shows a strong focus on the development of research in the circular economy, decreasing in matters related to Sustainable Design and becoming residual in Circular Design. It is noticeable that in both databases, searches carried out using keywords show a small amount of data compared to the remaining search variables. This observed behaviour demonstrates that the knowledge of the term is extensive, however, it is little applied as a focus of the investigation, evidenced by its (low) presence in keywords, usually used to direct directly to the subject to be addressed by the investigation. Likewise, it is understood that in the case of research carried out through WoS, the use of the term Design comes mostly from areas of Science and Technology as a result of the double meaning of the term in the English language, which in most cases intends to present the results of a project in these areas without a focus or approach on the part of the Design discipline.

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### **WoS Chronological Analysis**

The chronological analysis carried out through the data collected in the three variables shows a similar trend, with strong growth from the second decade of the 21<sup>st</sup> century onwards. This growth arises from a cause-effect relationship motivated by political and economic decisions to mitigate environmental problems and decarbonization. The data date the first incidences of information from 1980. The year 2021 presents an expressive and exponential volume of publications, representing a drop (by default) of the year 2022, due to the data collection date not considering the total universe in the year not yet finished, and this year's data should not constitute conclusive evidence.

## RCAAP Time Analysis

From the data collection carried out, it was observed the relevance of the study, its temporal evolution, in the mentioned areas, and understanding the relevance of the themes. The total data collected is concentrated on the time between 2007 and 2021. An exponential evolution is evident in research related to the 'circular economy, 'circular design' and 'sustainable design, for example in the 14 theses defended, 6 were concluded in 2020.

## Comparative Analysis

Although the RCAAP data only shows a time interval between 2016 and 2021, when compared with the WoS data, similar growth and an increasing trend are shown in both research and data universes. The growth of research on the subject demonstrates the opportunities and relevance of studying these issues to establish a relationship in line with the 2030 Agenda (2015), to mitigate the current problems faced related to the Anthropocene. The growth of research in the area is exponential (as already mentioned, it is noticeable in the two databases, according to the data collected in the Web of Science, 65% of the scientific production was carried out in the last 5 years, justifying the relevance and opportunity of research in Design applied to the Circular Economy.

## Qualitative Analysis

From the qualitative analysis, contributions were withdrawn, which, based on the selection of authors, demonstrate relevance to Circular Design, as an affirmative area of the Design discipline. It should be noted that authors such as Conny Bakker, co-author of "Products that Last", an important contribution to the definition and implementation of Circular Design tools, and Fiona Charnley with a vast investigation and study of concrete cases of application of Circular Design methods. Likewise, 3 doctoral theses were selected; by Doutor Diogo Riobom, for constituting in its genesis a project framed in the moulds presented by the ongoing research; Doctor José Vicente for his contribution to the development of methodologies applied to sustainable design and to allowing approximation to the adopted premises; Dr Raquel Oliveira for her contribution to the design in a sustainable way, based on the design for the formulation of more efficient coating products. In the case of the theses defended by Doctor Diogo Frias and Doctor Raquel Oliveira, the theses



constitute an investigation through the design project (research through design (Frayling, 1993) serving as a case study to understand the methods used and prove the form ( in Design) as a research laboratory, following the design science research thinking defended by Francisco Providência (2012; 2017; 2020).

## **Conclusion**

The knowledge of the term, and its (low) application in Design research, demonstrates the opportunity to deepen the study of the subject, through the presentation of theoretical and practical contributions, through the development of design projects based on these guidelines, in line with the claims and recommendations of the organizations fighting climate change, IPCC, European Commission and Agenda 2030. The emphasis given by these institutions to circular economy models also proves to be an opportunity for the growth and development of design on the subject, allowing it to assert itself as a discipline dedicated to the development of artefacts that can mitigate problems. and speculate on future problems, so that scenarios can be anticipated that do not put human beings at risk.

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