Using Product Design Strategies to Implement Circular Economy

Subjects: Agricultural Engineering
Contributor: Christian Spreafico

The design strategies referred to industrial design, e.g., user-centered design and timeless design were preferred by professional designers. The design strategies related to routine design, i.e., materials substitution, reducing resources and energy consumption, and structural optimization, were indistinctly used by both students and professional designers.

Keywords: eco-design ; teaching ; design strategies ; TRIZ ; circular economy

1. Overview about the Design Strategies

In the literature, design strategies of different types were proposed. At a macro-level, some design strategies support the designer through a more traditional approach, mainly aimed at structural optimization and based on small incremental changes, while others suggest more radical changes to the product, questioning its conceptual idea.

Typically, the first ones involve the mass reduction and the replacement of materials and components. While the second ones can instead stimulate to rethinking the design entities, e.g., Function, Product Behavior (e.g., Function-Behavior-Structure-FBS-theory [1]), to user-product interaction (e.g., [2]), and to a greater and more rational exploitation of the resources (e.g., TRIZ [3]).

Moreover, different design strategies suggest profoundly different ways of approaching a design activity. In structural optimization, the design strategies first support a functional, kinematic or dynamic analysis of the product structure and then the refinement of the same structure. While, in product innovation, the design strategies push the designer to immediately abandon the more concrete level of structural aspects and to work on a more abstract level, where the requirements, function and behavior of the product are re-discussed. Then, the strategies therefore suggest seeking abstract solutions to the initial problem, also reformulated in an abstract way and, at the end, to contextualize in line with the initial domain.

2. Applying the Design Strategies for the CE

Convinced that product design could support the transition to CE, some authors have therefore questioned which design strategies were most suitable for this purpose, comparing different ones within systematic reviews. However, although these contributions succeed in providing a general overview of the topic, at least three limitations, evident to any researcher analyzing the reference literature, must be overcome in order to ensure reliability to the obtained considerations.

In several studies, the considered application field concerns specific sectors, such as buildings construction (e.g., [4]) or fashion (e.g., [5]). While in other studies, only a certain area of design is considered, such as biomimicry (e.g., [6]) or user-centered design (e.g., [7]). In both cases, the resulting analysis is limited to only a few design strategies, typically applied in a restricted field and/or referred to the given design domain. Furthermore, this narrowness in the considered domain can also limit the number of considered CE strategies.

Another limitation present in some studies concerns their ability to suggest which design strategies can support CE and how. Some authors analyze only a few design strategies (e.g., [8]), reducing the number of possible comparisons. While others analyze the design strategies at a too high level of detail, considering the classes of design methods rather than to the single strategies [9][10] or explaining only the context information of a design activity or of a design framework that are more suitable for the CE (e.g., [11]). In both of these two cases it is not clear how a data design strategy can actually be applied to support the CE.

Finally, the literature does not provide an analysis specifically dedicated to students' problems and their limitations in applying the design strategies to favor the transition to the CE. Some studies describe only the typical problems of professional designers (e.g., [4][12]). Others propose instead generic considerations, having general validity for both professional designers and students (e.g., [7]).

On the reasons why, the teaching of CE concepts is only spreading in recent times, deepening only marginally on some aspects such as the role of design, several explanations from the literature were collected by [13]. According to the authors, theoretical knowledge is still too new and undeveloped in industrial practice. CE-based product development is even more recent and industrially applied only in a marginal way. The first regulations about CE practice have been adopted by the states only in the last five years. Teachings about CE described in the literature are few and too heterogeneous to provide an accepted reference. However, according to the same authors, teachers should not be discouraged from teaching the circular economy. On the contrary, due to the promising results presented in the literature about some experimental courses about CE and increasing industrial interest, CE teaching will spread rapidly in the coming years.

In conclusion, despite the best predictions for the future, at present the gaps between students and professional designers has not yet been studied in the literature.

References

1. Gero, J.S. Design prototypes: A knowledge representation schema for design. AI Mag. 1990, 11, 26.
2. Berni, A.; Borgianni, Y. Making Order in User Experience Research to Support Its Application in Design and Beyond. Appl. Sci. 2021, 11, 6981.
3. Altshuller, G.S. Creativity as an Exact Science: The Theory of the Solution of Inventive Problems; Gordon and Breach: Luxembourg, 1984.
4. Eberhardt, L.C.M.; Birkved, M.; Birgisdottir, H. Building design and construction strategies for a circular economy. In Architectural Engineering and Design Management; Taylor and Francis Ltd.: Oxfordshire, UK, 2020; pp. 1–21.
5. Moorhouse, D.; Moorhouse, D. Sustainable design: Circular economy in fashion and textiles. Des. J. 2017, 20 (Suppl. S1), S1948–S1959.
6. Mestre, A.; Cooper, T. Circular Product Design. A Multiple Loops Life Cycle Design Approach for the Circular Economy. Des. J. 2017, 20, S1620–S1635.
7. Wastling, T.; Charnley, F.; Moreno, M. Design for Circular Behaviour: Considering Users in a Circular Economy. Sustainability 2018, 10, 1743.
8. Benachio, G.L.F.; Freitas, M.D.C.D.; Tavares, S.F. Circular economy in the construction industry: A systematic literature review. J. Clean. Prod. 2020, 260, 121046.
9. Sumter, D.; De Koning, J.; Bakker, C.; Balkenende, R. Circular Economy Competencies for Design. Sustainability 2020, 12, 1561.
10. Bocken, N.M.P.; de Pauw, I.; Bakker, C.; van der Grinten, B. Product design and business model strategies for a circular economy. J. Ind. Prod. Eng. 2016, 33, 308–320.
11. Den Hollander, M.C.; Bakker, C.A.; Hultink, E.J. Product Design in a Circular Economy: Development of a Typology of Key Concepts and Terms. J. Ind. Ecol. 2017, 21, 517–525.
12. De los Rios, I.C.; Charnley, F.J. Skills and capabilities for a sustainable and circular economy: The changing role of design. J. Clean. Prod. 2017, 160, 109–122.
13. Kirchherr, J.; Piscicelli, L. Towards an education for the circular economy (ECE): Five teaching principles and a case study. Resour. Conserv. Recycl. 2019, 150, 104406.