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Implementation of an eco-innovation toolbox to stimulate design teams: a case of interior design

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Abstract

In the Fuzzy Front End of Eco-innovation, one of the main challenges of eco-ideation is the generation of ideas with a high level of environmental and socio-economical ambition. Current eco-design methods are not adapted to all the requirements of eco-innovation, because of 1) their complexity of implementation, 2) their low robustness and/or 3) their tendency to provide mostly techno-centred solutions. There is a need to define methods which can support multidisciplinary design teams to eco-innovate. In previous work, a set of seven didactical and meso Eco-ideation Stimulation Mechanisms (ESM) was developed, exploring systemic dimensions related to sustainability currently under-exploited.. The proposition first relies on the co-development of an intuitive and didactic formatting of an ESM toolbox to support the eco-ideation phase in multidisciplinary groups. Second, we propose a method in three main steps implemented in a four-hour workshop: a screening phase with the seven ESMs followed by an in-depth divergent phase with a single mechanism, and a convergent formalization of eco-innovative concepts. We illustrate the eco-innovation method by a real-world case study of an interior agency of a co-working building emphasizing circular economy principles and quality of life at work. A group of 13 stakeholders and experts (architects, eco-design experts, local authority and user representatives) were divided into three groups, facilitated by two researchers. The paper shows that this eco-ideation toolbox can be implemented in a real-life context of interior design in multidisciplinary groups involving multiple stakeholders. It supported the groups in sharing a common vision of interior design, and generating three original concepts of co-working spaces.

Keywords: eco-ideation; eco-innovation; stimulation mechanism; screening. interior design

1. Introduction

In recent years, sustainability goals tend to fit with the concept of the circular economy — that is to say an economy that close the loops and consequently aims at reducing waste flows [1]. Eco-innovation is a path to tend to a circular economy, through various strategies such as industrial ecology, biomimicry, innovative business models, etc. There are practical examples from industry, which underline that eco-innovation leads to reduce cost while capturing new opportunities and enhancing the reputation among customers (see for instance business cases for eco-innovation [2]).

The ALIENNOR research project brings a contribution to reach these goals in industrial contexts, and especially within small organizations like SMEs or startup companies. The objective of the 3-year project was to develop an eco-ideation approach based on easy to use creative tools, called Eco-ideation Stimulation Mechanisms (ESM), both didactic and accurate. These mechanisms explore systemic dimensions of sustainable development, poorly exploited so far yet very promising [3].

This paper presents a case study of implementation of the full eco-ideation approach. The application field is the green building expanded to healthy building [4], in the case of co-

working places. Co-working places have dramatically spread worldwide in the last years, and “offer a smart solution that integrates physical, virtual and social intelligence to the workplace concept used by an increasing customer segment of mobile workers” [5]. The aim is to cross eco-innovation and interior design, a topic not frequently addressed in the sustainable design community.

We first present some background notions in eco-innovation and eco-ideation, followed by sustainability considerations in interior design and construction (green-interior- building, healthy building, circular building). Then, the research protocol and case study on the interior design of a new co-working place are introduced (section 3). Results of the participatory eco-ideation workshop are provided in section 4. Section 5 concerns the limitations and scalability perspectives of a participatory eco-innovation process.

2. Previous works on eco-ideation and state of the art on sustainability in building and interior design.

2.1. Eco-Innovation and eco-ideation

Eco-innovation has been widely studied in literature. From a strong product-oriented definition [6], that is to say a process to develop environmental friendly innovative product or

services, eco-innovation is now considered as the emergence of product and services with a high level of environmental ambition, within a sustainable business model and considering relevant stakeholders of the whole value chain [7].

Within the eco-innovation process, eco-ideation is a crucial step, often under-estimated, and defined by Bocken et al. [8] as the phase during which ideas with great potential for reducing environmental impact are generated. Various research has been done in this topic, in particular to develop tools supporting design teams in the generation of eco-innovation ideas (see an overview in [9]).

In previous works [3;9], we underlined that eco-innovation and eco-ideation tools have two main shortcomings: (1) the level of specificity of the tool and the ideation mechanism it uses, as well as the level of problem definition. (2) The tools generally do not cover all the issues related to sustainability, yet promising in term of innovation, e.g. consumption patterns, territorial and local approaches, frugality, etc.

The ALIENNOR project is a tentative to overcome these shortcomings. To do so, seven Eco-ideation Stimulation Mechanisms (ESM) were identified through an iterative literature review and an empirical analysis [3]: (1) Innovate with stakeholders, (2) Innovate through biomimicry, (3) Innovate through sustainable mode of consumption, (4) Innovate through Product Service Systems, (5) Innovate through territorial resources, (6) Innovate through circularity, (7) Innovate through new technologies.

Each mechanism has an identical structure, leading to the following ideation process:

- (1) A characterization of the initial system and of the key components according to issue considered;
- (2) An identification of a set of ideation components to support the generation of ideas;
- (3) An idea generation of solutions in order to build a complete scenario or propositions for eco-innovation.

2.2. Illustration of an Eco-ideation Stimulation Mechanism: Innovate through Territorial resources

This section briefly exposes one of the mechanisms used for the case studied: “Innovate with territorial resources”. This mechanism questions the integration of territorial capital into strategy and project design. Territorial capitals cover natural capitals (resources, ecosystem services), the industrial capital, the social capital (skills, relationships with stakeholders, values, culture), as well as human capital (infrastructure, means of production, financing).

In the “Characterization of the initial system”, this ESM proposes to identify the different production and consumption sites on the life cycle of the system (product or service) and the capital that is mobilized.

Then for the “Identification of significant factors”, for each site, the ESM proposes to identify significant issues related to the territory around three contradictions, developed in [10]:

- (1) What is a local product/service embedded in a globalized system?;
- (2) What is the appropriate scale of production to reduce the environmental impacts?;
- (3) What is the relevant level of customization of the product / service to reduce the environmental impacts?

To finish, the “Idea generation” phase is articulated around the separation principles of TRIZ [11] to resolve contradictory requirements in time (Can the properties of the system be varied over time?), space (Can we vary the properties of the system according to the territory in which it is located?) or parts (Should all modules of the system have the same properties?). Through these three steps, the group is prompted to generate ideas with a territorial perspective, while reducing environmental impacts.

2.3. Addressing sustainability challenges in interior design and construction of buildings

Sustainability challenges in construction and interior design can be examined for residential buildings, public or commercial buildings. Seeking to define *green interior design*, Ning et al. [12] conducted a participatory workshop to elicit green building requirements for new residential buildings in China. They identified more than 30 indicators split into 5 categories: space performance, indoor environmental quality, energy efficiency, water conservation, material-saving. Xie, Clements-Croome and Wang [4] recommended to shift from green building (mainly focused on eco-efficiency) to *healthy building*, following the global growing attraction for well-being. They discussed the link between health, well-being and sustainability in the design and management of buildings, emphasizing that an integrated systemic approach is essential. Obrecht et al. [13] compared the coverage of health and well-being aspects by four international Building Certification Schemes. The analysis is based on five categories, which are air quality, access to water, to light, nourishment (food, farming), fitness, comfort (physical and physiological state) and mind (mental state). In the tradition of participatory design, Boess [14] reflected on the implementation of a zero-emission renovation project in the construction sector. She identified four main issues in the collaboration between designers and installation professionals. The issues concern (1) the goal translation, i.e. how sustainability goals are translated throughout the process; (2) the goal dissipation along the process; (3) the contested service interface resulting in a poor understanding of interface elements by residents; (4) the contested responsiveness of residents.

Leising, Quist and Bocken [15] designed a collaboration tool for the development and operation of *circular buildings*. They gave a definition of circular buildings emphasizing that “*materials are only temporarily stored in the building that acts as a material bank*”. They analysed three construction projects, one of which is a newly built office park. Six business models innovation strategies were more specifically applied to this case to create positive impacts or benefits, for instance to deliver functionality without ownership for lighting systems [15].

3. Research method

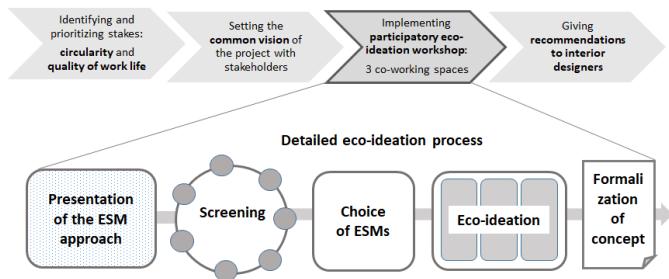
3.1. Case Study: A new co-working building project

The case study is related to the development of a new co-working building project, initiated by a French agglomeration. This project aimed at designing a building (called “Passerelle”) taking into account the circular economy and quality of working life stakes. The scope is the interior design of the future building, where recommendations are expected to feed the work of interior designers with appropriate requirements.

To do so, a first session, not considered in this paper, consisted to gather the different stakeholders in order to build a common vision of the project. Thanks to the different elements that emerged in the first session, the second step described in this paper, aimed at supporting the group in collectively generating concepts for the interior design of three working spaces, with a high ambition in terms of circular economy and quality of work life. The brief was set as follows: “How to eco-innovate on the interior design of a co-working building, to foster circularity and quality of life while mitigating their potentially adverse effects?”

Therefore, the approach is based on participatory design [16] supported by eco-ideation methods and tools (Fig. 1). A sample of 13 stakeholders and experts were invited to join the workshop organized by the commissioned consultancy after the first community meeting. The panel was

Fig. 1. Overall approach to design the interior of a new co-working building



set to balance main stakeholder groups, including the client – in this case local authority representatives, and also mix genders. Stakeholders and experts (including two researchers) involved in the workshop session are the following:

- Architects (1 person)
- Local authority representatives (2 persons)
- Interior designer (1 person)
- Eco-design consultants (4 persons)
- Furniture editor (1 person)
- Managers of co-working buildings (2 persons)
- Quality of work life consultant (1 person)
- Working space manager for a large company (1 person)
- Local politician (1 person)
- Human factors expert (1 person).

3.2. Setting of the eco-ideation process

It was decided to limit the study to three types of spaces which are expected to be sufficiently diverse in their functions and usages at the scale of the co-working building (Table 1): (1) closed office privatized by co-workers from large companies of the area; (2) open-space occupied by regular and one-day co-workers; (3) creativity room for affiliated or non-affiliated enterprises.

Prior to the participatory phases, the consultancy conducted a simplified life cycle assessment for the three spaces. Assumptions were made concerning the inventory, of furniture, electronic equipment and interior equipment (floor, walls and heating). The Functional Unit was “One square meter furnished for one year”. Main hotspots were characterized by a contribution for more than 20% on at least one indicator. Six indicators were selected for their relevance in the interior design sector: greenhouse gas emissions; particles emissions; resource depletion; radiations emissions and eco-toxicity. The results showed that extraction and production were the most impacting phases against all the indicators. Moreover, the electronic equipment is the most impacting for the three spaces on the majority of indicators, followed by interior equipment and furniture which also heavily contribute to environmental impacts.

The facilitation of the groups was ensured by two researchers (as participant observers) and one person from the consultant agency. Three groups were formed to work each on a different space, and were also asked to reflect on the connections between the different spaces in a holistic way. The results are based on:

- Written documents produced by the three groups along the phases of the eco-ideation process;
- A post-test online questionnaire (including 13 closed and 5 free comment questions) filled by 10 participants one week after the test; (partly reported in the paper);
- A post-test characterization of the generated concepts based on the health and well-being framework [13], conducted separately by the authors and discussed for consensus (not reported in the paper for brevity).

Table 1. Description of the three spaces of the co-working building.

Name	Main function(s)	Nb of occupants (max.)	Main users
Closed office	Privatized for teleworking	4	Co-workers from large companies (main target)
Open space	Work Conviviality Lunch break	12	Local entrepreneurs (regular/one-day)
Creativity room		16	Affiliated enterprises External enterprises

4. Results of the case-study: Eco-ideate on the interior design of a new co-working building

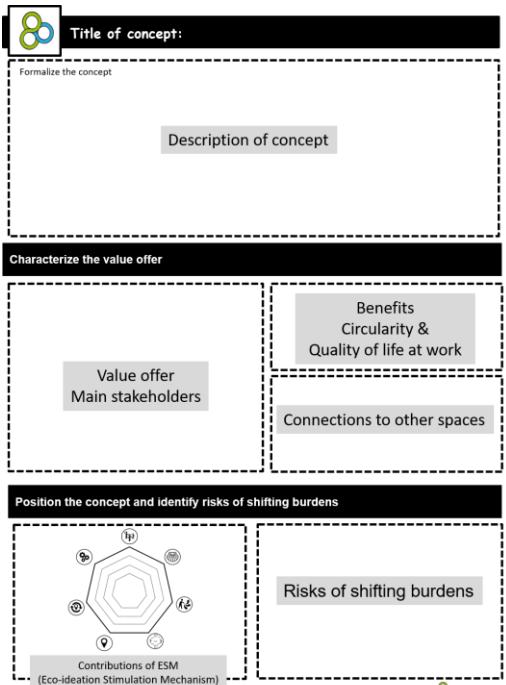
4.1. Results of the screening phase

The first step of the process proposes a reformulation of the design brief through each mechanism. In other words, each participant had to individually refine the initial problematic for each ESM. Secondly, the group was invited to collectively discuss their issues and then to select the mechanism they considered the more relevant for the design task. *We have noticed that this screening stage supports the groups both to refine the problematic and to generate a first set of ideas.*

The results of this stage was then translated into a global mind map by one of the author in order to better visualize the different issues developed by the groups. This mind map is centered on the following issue: “How to limit the environmental impact while improving” (1) the user comfort; (2) the furniture, the use of resources and equipment performance; (4) the data management; (5) the functionality of the different spaces; (6) the services; (7) the ability to communicate and to act on sustainability; (8) the development of a building at the heart of the social and economic stakes. A total of 51 items were generated. Amongst these items, 8 were oriented toward the quality of working life (for example the thermal comfort), 28 on environmental issues (for example the integration of local criteria for the purchase of furniture) and 15 ideas concerns both stakes (for example the mutualisation of IT services). From the screening stage, three mechanisms were considered as the most promising to generate the different concepts, see Table 2. Next section will focus on the second stage of the process.

Table 2. Selected ESM for the three spaces

Name	ESM	Key parameters	Caption
Closed office	Territorial resources	Personalization of the system, scale, local product vs. global system	The natural cocoon from local resources and crafting
Open space	Sustainable consumption	Eco-usage drift	The spirit of a frugal community



Creativity room	Product Service Systems	Added value (different user segments/services)	The 5 senses supported by a just need
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4.2. From the choice of eco-ideation mechanisms to an eco-innovative concept: illustration for the closed office

For brevity, we exemplify the results of the eco-ideation session for the closed office, the same process being followed for the other two. The numerous ideas were captured on post-it notes and clustered by the group into a formalized concept on a dedicated template (Fig. 2, adapted from [17]).

Fig. 2. Template of concept synthesis

Value offer for the closed office

For users of the closed office, the core value offer consists in the possibility to occupy a *closed, calm, fully-equipped* (furniture and digital equipment) and *customizable* space. Given the basic setting of walls and floors, it is possible to add noise absorbing, isolation and decorating materials. Territorial resources like tapestry fabrics and local oak and poplar wood are envisaged.

The second aspect of value offer is attached to the global service procurement (see 4.3, eco-labelled shop). The emphasis was made in the group on a local and sober management of digital hardware material and optimizing data storage.

About the potentially positive impacts on circularity and quality of work life, the benefits expressed for this space are mainly related to the environment and the circularity, such as the extension of the life of the electrical and electronic equipment used by the companies, thanks to the service Gateway purchase / leasing and maintenance, the potential reduction of the electricity consumption, paper, consumables (inks) thanks to the printing system and the choice of lighting,

or the use of recycled secondary material for floor and sound insulation (see Textifloor, Métisse®). In a more territorial view, the local value creation by soliciting local producers (textile, soil and insulation ...), carpenters and local organizations, local data storages, local networks of second life (Emmaüs, Envi2Nord ...) was underlined. Quality of working life was also identified, in particular in terms of improved comfort (light, thermal) and the development of specific services for everyday life.

Connections to other spaces

Firstly the closed office can be turned into an open office or another type of space if it is not booked, to optimize user rate and make full use of space resources (see Kojo and Nenonen, [5]). For printing, users are connected to a small printer at the same level or a large capacity colour printer in a dedicated printing room. For having a drink, regular beverages are available in the office, and more refined beverages are available from the cafeteria. For repairing or building one's computer, it is possible to use the fablab space.

4.3. From three concepts of working spaces to a global building concept

Two global ideas of services for the co-working building emerged from group discussions.

The first idea is to propose an *eco-labelled shop* for office consumables and digital equipment. The co-workers could be provided with a selection of small office materials (paper, ink, adhesive tape etc). The shop would also propose digital equipment for hire, refurbished equipment for sale (for example mobile phones like the Fairphone). This opens up new challenges, like for instance the type of management of the shop, the process of responsible suppliers' selection.

The second proposition concerns the *management of a co-working community*: organizing events for co-workers, educating to a sustainable management of one's digital data, to green IT. Once again, this implies to further define who would be in charge of this community dynamics. Lastly, the new building business model was evoked through the questions as follows: How to set the entry fees for co-workers (unique or variable depending on the type of users)? How to connect this offer to a mobility offer that would favour active and shared modes?

4.4. Perception of the process by the participants

To qualitatively analyze the eco-innovation workshop, the feedbacks of participants were required through an online post-test questionnaire. Even if authors agree that this sample is not sufficient to have a reliable understanding of the perception of the workshop, it gives some relevant information on the toolbox, and on the overall method.

Concerning the toolbox, it was noted that the playability could be enhanced, for instance with tokens and simplified stages for mechanisms. Two participants also expressed the need for examples to provide a simple and visual understanding of the mechanisms.

Concerning the feedback on the overall method, the idea generation stage was mentioned several times (N=4) as the most important and productive one, but because it was enabled by the screening session of the morning. The morning session was perceived as less guided and fuzzy. One of the participant (furniture editor) reported to be unsure about what to do at first, but was eventually very impressed by the whole process that conducted to "*collectively create a result that appears of great quality*". For one of the eco-designers, the ESMs allowed to "*generate ideas without noticing it*". The multidisciplinary of the group was judged very important to enrich the discussion, in line with Xie, Clements-Croome and Wang [4] who emphasize a broad stakeholder involvement in the development and implementation of solutions for healthy buildings.

5. Conclusion and further work

The focus of this paper is the implementation of an eco-ideation tool in the context of interior design. We have first introduced the notion of Eco-ideation Stimulation Mechanism (ESM), and the exposed challenges of green and healthy building design. The second part of the paper presented a workshop of implementation of the ESM approach on "How to eco-innovate on the interior design of a co-working building, to foster circularity and quality of life while mitigating their potentially adverse effects?". We illustrated the full eco-ideation approach for one of the three co-working spaces (i.e. the closed office), and reported the perception of the eco-ideation session by the participants.

We showed that the eco-ideation toolbox, initially developed and tested in controlled conditions with experts in sustainability at large, industrial designers, SMEs and students in academia, could also be implemented in a real-life context of interior design in multidisciplinary groups involving multiple stakeholders. Generated along a one-day workshop, the results appear to be satisfactory for the stakeholders in a shared and embedded vision of interior design. The concepts generated for the three co-working spaces were further translated into recommendations illustrated by mood boards, and into a set of requirements to feed the call for tender. The requirements supported the selection of interior designers and companies, currently in its final decision stage.

The participatory process presented in Fig.1 could be duplicated (as "participatory eco-innovation") in other contexts, to deal with urban life issues at a local or regional level. Nevertheless, due to time restriction, some elements could not be investigated and led to some limitations:

- Regulatory aspects related to green buildings and confrontation with dedicated guidelines like those from the BREEAM certification.
- Cost issues in green or healthy building planning. Indeed the cost challenge was mentioned by the local authority stakeholders. In fact, extra costs were addressed in a posterior step for the call for tender.
- Setting more specific and quantified targets for circularity and quality of work life to specify the eco-innovative ambitions, and mitigate risk to deviate

from the initial ambitions, as pointed out in [14]. However, targets were specified in a posterior step and added to the requirements list for the call for tender.

Through this pilot study, we finally advocate for developing a replicable participatory approach based on eco-ideation principles at a regional level to nurture public or public-private initiatives with strong sustainability ambitions.

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