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Conceptualization in the circular economy: Analysing the influence of thinking profiles in creative groups

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ABSTRACT

Eco-innovation initiatives include eco-ideation processes for proposing ideas that are innovative and represent an environmental improvement. The evaluation of the results of eco-ideation has been focused on evaluating these two aspects, but it is necessary to know how related factors, such as the thinking profile of group members, influence the generation of concepts during the creative process. This study proposes a metric that analyses the results of the creative process within conceptualization from three approaches: innovation, circularity and group activity. The group activity approach is related to the influence of the leader in the management of a creative group. The proposed metric allows us to observe the creative process, the interactions among the participants, the design decisions made, and the evaluation of the creative product which will determine which type of creative groups obtain better results. The application of the results and the proposed metric allow the creation of groups oriented to objectives, for both specific or permanent workgroups. This can be used for the initial selection of participants for eco-ideation groups, or to improve the group functionality during intermediate stages.

1. Introduction

Eco-innovation is intended to prevent or reduce environmental impacts of the use of resources during the generation of novelty in products, production processes or services, or in management and business methods (OECD, 2009; Schiederig et al., 2012). It includes an eco-ideation phase during the early stages of the development process, structured (O'Hare et al., 2014) with specific tools for idea generation (Tyl et al, 2013, 2015) and selection (Vallet et al., 2013; Vallet and Tyl, 2019). The diversity of tools for eco-ideation is limited (Tyl et al., 2015); such tools are very theoretical, little used and complex (Bocken et al., 2011). However, there are some processes which can be applied to workshops and eco-ideation sessions (López-Forniés and Sierra-Pérez, 2019; Mestre, 2015; Sierra-Pérez et al., 2016; Tyl et al., 2018) focusing on the preparation phase, in order to select the creative group and to provide supporting information, techniques and evaluation metrics.

The amount, reliability and relevance of the environmental information shared during eco-ideation processes (Collado-Ruiz and Ostad-Ahmad-Ghorabi, 2010) is crucial in order to obtain final concepts with real environmental improvements. Therefore, the level of knowledge and environmental awareness of each participant of the creative group exercises a considerable influence (Paulus, 2000). Usually, the participant who manages the creative dynamics and how ideas are built is the leader of the group (Amabile and Khaire, 2008), and is supported by co-creation. Therefore, a suitable option for eco-ideation processes is for the leader to be an environmental specialist. It is intuitively believed that the environmental profile of the leader and the multidisciplinary configuration of the group affect the results of co-creation workshops.

The main aim of this study is to propose a metric to evaluate the influence of group composition and the thinking profile of leaders on the management of the environmental information that it is used during the creative process of eco-ideation. The assessments to date have been focused on environmental improvements, technical feasibility, novelty, or the usefulness of final ideas and solutions (López-Forniés et al., 2017). But it is also necessary to know how these ideas were obtained and managed, as well as the composition of creative groups, related to expertise and thinking profile of each participant.

The remainder of the article is structured as follows. Section two describes the theoretical background related to the proposed metric. Section three presents the methodology with details of the process of the metric design. Section four describes the results and explains how the metric can be applied to a real case. Section five, the interpretation of

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results and discussion, presents the different approaches that the metric can have and their implications. Section six sets out the conclusions with remarks on the most relevant contributions of the metric.

2. Theoretical framework

The theoretical approach to group activity used in this study is related to the influence of the leader in the management of a creative group. The group is presented from the systemic perspective as an integrated and synchronous 'unit of action' (Aiger, 2013; O' Connors, 1980; Von Crannach, 1996). The group is more than the sum of its members, and a change in any of its participants produces a modification in the rest (Lewin, 1951). This perspective allows studying the influence exerted by the leader during the action of work groups to achieve the objectives (Gil Rodríguez and Alcover de la Hera, 2005; Palacín and Aiger, 2014; Yukl, 2010). Traditionally, the leadership approach on styles has based scientific activity and there is a strong trend in research on the competencies and abilities of the leader. It can influence in more competitive, adaptable, and flexible groups and teams (Yao et al., 2021), managing individual and group creativity in order of being more sustainable in the process of creating and innovating (Hu et al., 2018; Huang et al., 2020; Robu et al., 2019). Some studies reveal that collaboration, and having a common goal, improves group performance (Bittner et al., 2016), as well as the thinking profile of the members (Chulvi et al., 2020).

The literature shows that the most widespread assessment methods for eco-ideation processes are, on the one hand, metrics focusing on the creative product and the environmental contribution without taking into account the interaction of the group. On the one hand, the novelty factor is the most common in existing metrics (E Jones et al., 2001a,b; Nelson et al., 2009; Oman et al., 2013). On the other hand, recently eco-ideation metrics that include the environmental dimension have been presented (Hansen et al., 2011; López-Forniés et al., 2017; Ruiz--Pastor et al., 2020; Vallet and Tyl, 2019). The analysis of groups in eco-ideation research is still limited. In these cases, qualitative methodologies are used, mostly interviews and questionnaires (Harris et al., 2021; Marcello Falcone, 2018). From the psychosocial perspective, a multilevel analysis design is used (Mathieu et al., 2019). Moreover, classical methodologies for the analysis of groups at intergroup level related to circularity initiatives, such as Game Theory, have been used to analyse the power and influence of relationships between interest groups (Yunan et al., 2021). However, it is necessary to evaluate quantitatively the performance and functionality of creative groups at group activity level. In this regard, DISC (Bonnstetter and Suiter, 2016) is an evaluation instrument used to identify the competencies and abilities of the leader in the strategic management of work groups, generating four different profiles. DISC is agile, functional and used in personnel selection processes, and leadership and management studies in organizations (Bonnstteer et al., 2014; Fuel et al., 2021). These profiles define how the leader's style influences the development of the group's co-creation process. On the other hand, at intragroup level, the evaluation protocol 'Group Activity Analysis' (GAA) (Vicente et al., 2006) allows a quantitative variable of the psychosocial variable 'positivity' to be extracted, in order to explain the functionality of the group. The importance of this work lies in implementing the GAA to measure the group at the intragroup analysis level, since in most group measurements the sum of individualities is used from an intrapersonal perspective.

The existing approaches of metrics focused on novelty and environmental dimensions together with instruments for the quantitative evaluation of group activity can complement the assessment of eco-ideation results considering also the human factor and how the composition of creativity groups and the type of thinking profile of the leader can influence their work. On the one hand, the proposed metric introduces a measurable and quantitative evaluation of the different factors that influence during the creative process. On the other hand, this evaluation will be carried out intragroup, not from an individual approach of each member of the creative group.

3. Methodology

The methodology is workshop-based and was tried out in different sessions with four multidisciplinary groups with the same composition of experts. Fig. 1 shows the structure of the methodology followed to build the proposed metric.

3.1. Preparation of the creative process

The proposed methodology, searching for new concepts, consists of a process that has been built by running creative workshops differentiated between them by the thinking profile of each leader, describing four different styles of thinking and team management.

3.1.1. Design of the experiment

The creative groups have five members each, being the environmentalist the leader for all groups. Each session was held under the same circumstances regarding the environmental challenge, the duration and the physical conditions of the workspace.

The selection of the challenge to address has to meet certain requirements: an everyday topic of which all participants have experience. The challenge should not be of high complexity in order to be easily understood and fully addressed in the planned sessions. Based on the above, the proposed objective is of considerable environmental concern:

How to transport and market 50 cl of spring water in substitution of the current plastic water bottles considering all life cycle stages.

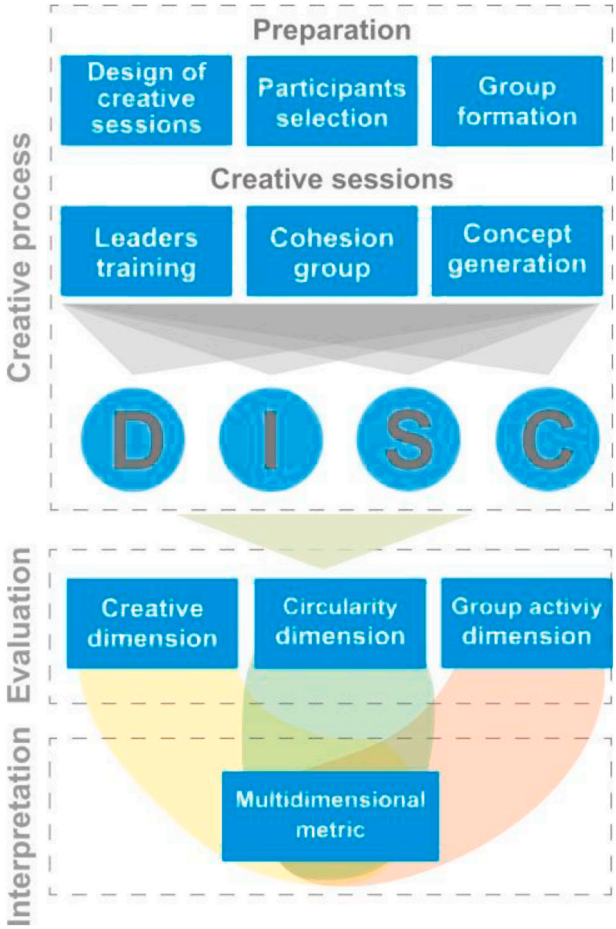


Fig. 1. Scheme of the methodology.

3.1.2. Selection of participants

As previously commented, the environmentalist in each group will act as the group leader. Each leader of the four groups will have a different profile based on the DISC thinking pattern (Bonnstetter and Suiter, 2016).

The first condition for selecting the leaders was that they should all be active experts from Spanish R + D + I institutions, more specifically in the field of eco-design and circular economy. Some experts were identified according to these requirements, and four of them, one per DISC profile (Table 1) were chosen.

Before the creative sessions, the group leaders received instructions from the organizers regarding objectives, activities and role playing during the session. Additionally, brief documentation was provided to highlight the main guidelines to consider.

The other group members had an interdisciplinary expert profile in product design and creativity, marketing and engineering. On the one hand, the experts in product design and creativity were the creative core with a divergent profile, having unfocused thinking and looking for new connections to ideate new concepts, searching for novelty. On the other hand, the experts from marketing focused on the market opportunity. The engineering experts concentrated on generating an appropriate solution that meets the proposed challenge. Moreover, the reasons for the participants' selection were based on gender, age, and level of field expertise, balancing these factors in each group.

3.2. Design of the creative process

3.2.1. Description of sessions

Table 2 shows the activities of the workshop, the type of information used, the communication between the coordinators and the participants, the techniques or tools used, and the verification of the information used. The documents necessary to carry out the group activity are presented in the Supplementary material to allow replicability of the workshop. Supplementary material also presents the structure of the sessions, divided into three main parts, following an action protocol to indicate the development of the group's activity: (1) P indicates activities prior to the start of the workshop, (2) D indicates the activities carried out during the workshop, and (3) C indicates the period of closing of the workshop with the evaluation of the group activity.

3.2.2. Data management

A multiple registration system is used during the sessions, avoiding the loss of information and ensuring reliability (Berman and Kim, 2010). The information is in paper format to record ideas, diagrams and drawings as in other eco-innovation sessions (E. Jones et al., 2001). Photographs of the blackboards and sticky-paper are included as graphic material. Workshop sessions recorded in video (video, audio, and transcripts) (Shroyer et al., 2018) are useful for documenting idea discussions and tracing idea generation through time, and for preserving details such as gestures, confrontation, etc., for group activity research. Table 2 compiles all this information.

Table 1
Description of four types of thinking profile according to DISC methodology.

D	Dominance	Refers to action-oriented behaviour, decision making and ability to take risks.
I	Influence	Refers to a person-oriented profile, interaction and interpersonal relationships where persuasion is used.
S	Stability	A behaviour profile aimed at maintaining balance, harmony and the "status quo" in a safe environment.
C	Compliance standards	Guides behaviour towards the investigation of data and information, the quality of the processes in the tasks and an orientation towards rigor in the investigation.

3.3. Assessment of results of the creative sessions

3.3.1. Metric description

The main theoretical question is: How can the knowledge of the leader and his/her thinking profile influence the results of a creative process? For this purpose, an original metric is proposed for the evaluation of results, including the three main dimensions in this research: creativity dimension in terms of its innovation, the environmental dimension through the circularity performance, and the influence of the group composition.

Each metric dimension (Creativity-Cr, Circularity-Ci and Group Activity-GA) is divided into specific sub-dimensions: Creativity (Novelty-N, Usefulness-U, Feasibility-F), Circularity (Narrowing-N, Slowing-S, Closing-C) and Group Activity (Interaction-Ia, Interdependence-Id, Exchange-Ex). This will be explained in the following sections. The three sub-dimensions score on a 5-point scale [0.1, 0.3, 0.5, 0.7, 1] with a centerpoint, unlike evaluations with a 4-point scale (Kudrowitz and Wallace, 2013; López-Forniés et al., 2017; Srivathsavai et al., 2010). All dimensions will range from 0.1 to 1, avoiding starting from 0 to prevent a null score on various concepts. In the case of Circularity, three sub-metrics relate to each sub-dimension, scoring a 5-point scale [-2, −1, 0, +1, +2], adding each sub-dimension to obtain a final score. This final score transforms to the 5-point scale [0.1, 1], as with the other dimensions. Using sub-metrics in circularity sub-dimensions responds to the need of scoring negative values for a worsening of the baseline situation and positive values for improvements, while 0 means that the concept contributes neither to an improvement nor to a worsening with respect to the existing situation. The following equation explains how to calculate the CP:

$$CP = Cr[(N * U * F)[0.1, 1]] * Ci[(N * S * C)[0.1, 1]] * GA[(la * ld * Ex)[0.1, 1]] \quad (1)$$

3.3.2. Creativity dimension assessment

The creativity dimension is assessed by the adapted NUF test (Kudrowitz and Wallace, 2013) *Novelty* (N), *Usefulness* (U) and *Feasibility* (F), focusing on marketability. Novelty is compared to the newness of the products on the current and past market. Feasibility considers the possibility of the idea being developed technically and also the economy of resources (investment y and time). Usefulness refers to how the concept surpasses existing products by means of a new use or an improvement. Table 3 presents the criteria to evaluate each sub-dimension:

3.3.3. Circularity dimension assessment

This assessment focuses on the alignment of generated ideas with circular economy strategies and improvement of the ideas life cycle with respect to a reference product (EPD System, 2014). The sub-dimensions focus on the following circular strategies: Narrowing (Use less), Slowing (Use longer) and Closing (Use again) (Bocken et al., 2016; Konietzko et al., 2020). Each Circularity sub-dimension is composed of three factors, Material use (M), Energy use (E), and Transport loads (T), to refine the evaluation in a more accurate way, since these strategies are very general. Tables 4–6 present the description of values for each factor in the sub-dimensions: Narrowing, Slowing and Closing. The following equations explain how to score each sub-dimension and each related factor:

$$N = (M + E + T)[-2, 2] \quad (2)$$

$$S(M + E + T)[-2, 2] \quad (3)$$

$$C(M + E + T)[-2, 2] \quad (4)$$

$$Ci = N[0.1, 1] * S[0.1, 1] * C[0.1, 1] \quad (5)$$

Narrowing expresses the quantity of products, components, materials

Table 2
Description of activities developed in creative sessions and indicating the generation of information and its management.

	Activities	Information	Communication	Creative technique	Tools	Check
P	Leader selection	Review and selection of various profiles to fit into DISC	Conversation between coordinators	Bonnstetter and Suiter (2016)	DISC	According to DISC protocol criteria
P	Instruction to the leader	Guidelines (see guidelines document) Timing	From coordinators to leaders	–	Guidelines document (Annex A1). Video recording with instructions	P. Receipt of mail, understanding and resolution of doubts. D. Observation of compliance with the activities
D	Group presentation	Warming-up. Get to know each other and group cohesion	Intragroup, everyone with everyone	–	Icebreaker	Observation of compliance with the definition of your group identity (name)
D	Explanation of activities	Presentation by the leader of the environmental challenge to be addressed	Intragroup, from the leader to the group	–	Script with instructions	Check compliance with instructions
D	Task 1	Search for water properties "X" to protect	Intrapersonal: Fill out Post-it individually Intra-group: Present the ideas with the rest of the group, combine and rank them. Selecting the most relevant for all members of the group	Dimensional Brainswarming (McCaffrey, 2018) Affinity diagram (Widjaja et al., 2014)	Task 1 sheet (Annex B1)	Observation of compliance with the activity
D	Task 2	Search for "Y" current environmental impact problems of mineral water containers	Intrapersonal: Fill out Post-it individually Intra-group: Present the ideas with the rest of the group, combine and rank them. Selecting the most relevant for all members of the group	Dimensional Brainswarming (McCaffrey, 2018) Affinity diagram (Widjaja et al., 2014)	Task 2 sheet (Annex B2)	Observation of compliance with the activity
D	Task 3	How to package water conserving "X" property and avoiding "Y" environmental problem?	Intragroup: Fill out the task3 sheet	"Forced relationships" or "Random stimuli" (De Bono, 1990)	Task 3 Sheet (Annex B4)	Observation of compliance with the activity, make the combinations
D	Task 3	Idea selection	Intragroup:	Forum-style conversation	Discussion among the participants	Observation of compliance with the activity established
D	Task 3	Idea development	Intragroup:	Forum-style conversation	Discussion groups	Observation of compliance with the activity, fill in the form with the idea generated
D	Presentation of the result of the concept	Concept description, design specifications, characteristics, details, etc.	Presented by the leader Coordinators asking questions to clarify doubts	–	Task 3 Sheet completed	Observation of compliance with the activity
C	Fill Protocol GAA sheet	Intrapersonal assessment of the developed group activity (intragroup)	Intrapersonal	GAA protocol (Vicente et al., 2006)	GAA protocol sheet (Annex B5)	Observation of compliance with the activity and later analysis

and energy used during the different life cycle stages of the proposed product/service. Additionally, it evaluates the level of transport load, including both the distribution and the end-of-life stages, as well as during its use and maintenance. The principle of this circular strategy is 'design with low-impact inputs.

Slowing expresses the capacity of products to be reused, completely or partially, or to be repaired or updated (Table 5). Additionally, the level of intensity of product use is evaluated, including sharing and multifunctionality. The principle of this circular strategy is 'design for physical durability', being more durable, and its function is extended more slowly over time than comparable products on the market. This factor is expressed in three subfactors: Reusable and Remanufactured, Repairable and Upgradeable, and Use Intensity.

Closing refers to maintaining the highest value of materials possible, bringing post-consumer waste back into the economic cycle (Table 6). A product principle for closing is 'design with materials suitable for primary recycling'. This factor is expressed in three subfactors: Waste generation, Recycling capacity, and Recycling quality (Bocken et al., 2016).

3.3.4. Group activity dimension assessment

Finally, it is necessary to see how the creative process is carried out and to determine the influence between the type of thinking profile, the knowledge of the participants and the creative product result. There are two types of assessment instruments to measure group activity: qualitative by means of the DISC and the metric for the group activity dimension (face-to-face observational methodology and review of audio-visual recordings are used to extract the content of the metric), and quantitative with the Group Activity Analysis (GAA) protocol.

Group activity is assessed by three sub-dimensions: Interaction, Interdependence and Exchange. These sub-dimensions define the group's activity at the conceptual level (Aiger, 2013; Gil Rodríguez and Alcover de la Hera, 2005). Each subdimension relates to the activity of the group itself and participants within the group at three different stages of the session: Phase 1 (Ph1) the presentation and the first task, Phase 2 (Ph2) the second and the third task, and Phase 3 (Ph3) the sharing of the outcomes between groups.

The values for each subdimension range from the maximum activity of the group to the interpersonal interaction (Table 7). Interaction describes how participants interact, defined by more or less communication within the group. Interdependence describes cooperation and mutual dependence between participants. Exchange describes the amount of resources (cognitive, procedural and emotional) that are given and received in the group. Feedback, incorporated into exchange, describes objectively, punctually, neutrally and technically which elements are useful for the group and which are not, and thus modifies them to benefit the operation of the team.

The Group Activity Analysis (GAA) Protocol based on the Munné (1985) group activity model was used for the quantitative assessment. The GAA application protocol is a semantic differential made up of 16 bipolar scales (Table 8) using pairs of antonym adjectives. In this case, only the positivity values of the GAA Protocol for the DISC groups are

Table 3
Metric proposed to evaluate the creative sub-dimensions for each concept.

Novelty (N)	Score	Means
High novelty	1	The product derived from the concept will be new, it does not exist or cannot be compared to other existing products in the market.
Medium novelty	0.7	The concept already exists as a product but provides some novelty for a conceptual difference in the market.
Low novelty	0.5	The concept presents a similar or equal solution to existing products in the market. There is little or no differentiation.
Without novelty	0.3	The concept presents an old idea previously used in the market and discarded by other products that perform better nowadays.
Old fashioned "oldness"	0.1	The concept presents an outdated idea and there are various generations of new product solutions existing in the market.
Usefulness (U)	**Score**	**Means**
High usefulness	1	The concept solves originally an existing need or problem or else is the solution for a new application.
Medium usefulness	0.7	The concept solves part of an existing need or problem; The concept only applies to certain aspects of the solution.
Low usefulness	0.5	The concept solves part of a problem under certain circumstances. There is little utility improvement compared to existing products.
Without usefulness	0.3	The concept does not perform a better solution to any existing need or problem or else is not a solution for a new application.
High non-utility	0.1	The concept presents a solution that is useless, or the application is worse than the existing solutions.
Feasibility (F)	**Score**	**Means**
High feasibility	1	The concept can be made in an easier way without any investment and in a shorter period of time compared to existing products.
Medium feasibility	0.7	The concept can be made with current technology or in a shorter period of time compared to existing products. Needs low investment.
Low feasibility	0.5	It is made as other products in the market, with the same technology and period of time. Needs investment.
Without feasibility	0.3	The changes needed, either structural or radical, are difficult to achieve, the need for investment or time is high.
Impracticability	0.1	The concept is difficult to be made technically, the idea is fanciful and unreasonable. The need for investment and time is high.

evaluated. High positivity values (POS), higher than 4 on the Likert scale, indicate high functionality, interaction and interdependence; and also, high exchange to achieve the group objective. Groups with a low value, up to 4 points, indicate difficulties with optimal functioning in the group.

3.4. Interpretation of results

To evaluate the influence of group activity, three options are established for the metric. M_1 only considers the input (problem to be solved) and the output (objectives achievement of objectives), ignoring the group activity, as a black box vision (López-Forniés et al., 2017). M_2 and M_3 regard the process as a transparent box, observing leader and group activity. M_2 only considers the group activity dimension from the metric, and M3 also includes the group positivity (POS) as a factor.

$$M_1 = Creativity{*}Circularity \tag{6}$$

$$M_2 = M_1 * Group\ Activity\ =\ (Creativity\ *\ Circularity) * Group\ Activity \tag{7}$$

Table 4
Metric proposed to evaluate the Narrowing strategy by each concept.

Narrowing (N)		
Material use (MU)	Score	Means
High reduction	2	The concept partly or totally reduces the complexity of products, minimising the number of materials and components used.
Medium reduction	1	The concept reduces slightly the complexity of products, minimising the number of materials and components used.
No changes	0	The proposed concept contributes neither to an improvement nor to a worsening with respect to the reference product.
Medium increasing	−1	The concept increases slightly the complexity of products, with a higher variety of materials and components.
High increasing	−2	The concept increases greatly the complexity of products, with a higher variety of materials and components.
Energy use (EU)	**Score**	**Means**
High reduction	2	The concept partly or totally minimises the energy consumption during the manufacturing processes and product use.
Medium reduction	1	The concept minimises slightly some of the following aspects: the energy consumption during manufacturing processes or during product use.
No changes	0	The proposed concept contributes neither to an improvement nor to a worsening with respect to the reference product
Medium increasing	−1	The concept increases slightly some of the following aspects: the energy consumption during manufacturing processes or during product use.
High increasing	−2	The concept experiences an important increase of the energy consumption during the manufacturing processes and product use.
Transport loads (TL)	**Score**	**Means**
High reduction	2	The concept partly or totally reduces the transportation loads during the beginning and end of the product's lifetime, as well as for the need not to be transported for maintenance or repair reasons.
Medium reduction	1	The concept reduces slightly the transportation loads of products, minimising journeys travelled during the beginning and end of the product's lifetime, or during its use phase.
No changes	0	The proposed concept contributes neither to an improvement nor to a worsening with respect to the reference product.
Medium increasing	−1	The concept increases slightly the transportation loads of products, extending some journeys travelled during the beginning and end of the product's lifetime, or during its use phase.
High increasing	−2	The concept increases greatly the transportation loads during the beginning and end of the product's lifetime, as well as the need to be transported for maintenance or repair reasons.

$$M_3 = M_2 * POS = (Creativity * Circularity * Group\ Activity) * POS \tag{8}$$

4. Results

This section presents the results obtained in the four sessions carried out during the experiment by each creative group, and the application of the proposed metric and its different interpretations.

4.1. Creative process results

From the video recordings and registration sheets that each of the leaders filled in, Supplementary material (Annex C1) shows the results that will be evaluated with the proposed metric. For the given time and

Table 5
Metric proposed to evaluate the Slowing strategy by each concept.

Slowing (S)		
Reusable and Remanufactured (RR)	Score	Means
High increase	2	The concept increases the capacity of reusing some component of the product in other product, increasing its durability.
Partial increase	1	The concept increases the capacity of the product to remanufacture, using product's components in the manufacturing of other product.
No changes	0	The proposed concept contributes neither to an improvement nor to a worsening with respect to the reference product.
Partial reduction	−1	The concept reduces the capacity of the product to remanufacture, not using product's components in the manufacturing of other product.
High reduction	−2	The concept reduces the capacity of reusing some component of the product in other product, avoiding the increase of its durability.
Repairable and Upgradeable (RU)	**Score**	**Means**
High increase	2	The concept increases the capacity of the product to be repairable and upgradeable during the use phase, increasing its lifetime.
Partial increase	1	The concept increases the capacity of the product to be repairable during the use phase increasing its useful life, but not upgradeable when the product is outdated.
No changes	0	The proposed concept contributes neither to an improvement nor to a worsening with respect to the reference product.
Partial reduction	−1	The concept reduces the capacity of the product to be repairable during the use phase, increasing its useful life.
High reduction	−2	The concept reduces the capacity of the product to be repairable and upgradeable during use phase, shortening its lifetime.
Use intensity (UI)	**Score**	**Means**
High increasing	2	The concept increases significantly the intensive use of the product, including its multifunctionality and shared use.
Medium increasing	1	The concept increases slightly the intensive use of the product, including either multifunctionality or shared use.
No changes	0	The proposed concept contributes neither to an improvement nor to a worsening with respect to the reference product.
Medium reduction	−1	The concept reduces slightly the intensive use of the product, eliminating either its multifunctionality or its shared use.
High reduction	−2	The concept reduces significantly the intensive use of the product, eliminating its multifunctionality and shared use.

considering the very focussed objective, the results are acceptable and comparable among themselves.

4.2. Assessment of creative results

This section presents the evaluation of the results for each group by factors of the proposed metric: creativity, circularity and group activity (Table 9). Additionally, for group activity, Table 10 shows the evaluations applied to the three variables of the group activity metric during the creative process. In addition, the data obtained with the GAA protocol (positivity only) are presented. Descriptive statistics are applied with the calculation of means and standard deviation (M, SD) to calculate the levels of group activity and positivity in the different creativity groups (D, I, S, C). The total of the evaluations obtained by the twenty participants of the creative groups generates N = 320 records.

Table 6
Metric proposed to evaluate the Closing strategy by each concept.

Closing (C)		
Waste generation (WG)	Score	Means
High reduction	2	The concept partly or totally eliminates waste through its life cycle, considering volume and weight factors.
Medium reduction	1	The concept eliminates slightly waste through its life cycle, considering volume and weight factors.
No changes	0	The proposed concept contributes neither to an improvement nor to a worsening with respect to the reference product.
Medium increasing	−1	The concept increases slightly waste through its life cycle, considering volume and weight factors.
High increasing	−2	The concept experiences an important generation of waste through its life cycle.
Recycling capacity (RC)	**Score**	**Means**
High increase	2	The concept partly or totally increases the capacity of recycling of the product's components due to their material nature and their disassembly capacity.
Partial increase	1	The concept increases slightly the capacity of recycling of some of the product's components due to their material nature and their disassembly capacity.
No changes	0	The proposed concept contributes neither to an improvement nor to a worsening with respect to the reference product
Partial reduction	−1	The concept reduces slightly the capacity of recycling of some of the product's components due to their material nature and their disassembly capacity.
High reduction	−2	The concept partly or totally reduces the capacity of recycling of the product's components due to their material nature and their disassembly capacity.
Recycling quality (RQ)	**Score**	**Means**
Allow for primary recycling	2	The concept increases the capacity of recycling of the product's components by reprocessing their materials for the retainment or improvement of the properties of the material. Upcycling.
Allow for secondary or tertiary recycling,	1	The concept increases the capacity of recycling of the product's components by reprocessing their materials into a "low" value product, Downcycling. Or recovery of the chemical constituents of a material obtaining equivalent properties to the original material.
No changes	0	The proposed concept contributes neither to an improvement nor to a worsening with respect to the reference product.
Avoid secondary or tertiary recycling,	−1	The concept reduces the capacity of recycling of the product's components by reprocessing their materials into a "low" value product, Downcycling. Or recovery of the chemical constituents of a material obtaining equivalent properties to the original material.
Avoid primary recycling	−2	The concept reduces the capacity of recycling of the product's components by reprocessing their materials for the retainment or improvement of the properties of the material. Upcycling.

4.2.1. Group #D

Group #D applied and developed the proposed creative process satisfactorily. They suggested a service that conceptually exceeds the initial expectations because it explores a more complex form of water marketing. The complexity meant that the definition was less detailed because of the short time available. Concept #D is characterized because the consumer does not own the bottle, based on waste control,

Table 7
Description of the group activity metric.

Interaction (Ia)	Score	Means
In Group	1	Maximum level of interaction where everyone talks to everyone else. Group level communication.
Subgroups	0.7	Average level of interaction where communication occurs at the subgroup level (working subgroups are generated).
Interpersonal	0.5	Level of interpersonal interaction in the group. Two-dimensional communication.
Intrapersonal	0.3	Intrapersonal level, where one speaks and the rest listen. One-dimensional communication.
No interaction	0.1	There is no interaction between group participants.
Interdependence (Id)	**Score**	**Means**
In Group	1	Maximum interdependence, where all group participants cooperate and depend on each other at the group level to achieve the goal.
Subgroups	0.7	Medium level of interdependence, where group participants cooperate and depend on each other at the subgroup level to achieve the goal.
Interpersonal	0.5	Level of interaction where cooperation occurs at an interpersonal level to achieve the objective.
Intrapersonal	0.3	Interaction level where there are difficulties in cooperation, and the activity is developed at an intrapersonal level to achieve the objective.
No interdependence	0.1	There is no interdependence in the work group; being the sum of individualities.
Exchange (Ex)	**Score**	**Means**
Feedback Intragroup	1	The whole group exchanges resources (cognitive, conative and emotional) during the group activity. In-group exchange (everyone with everyone). Intragroup feedback.
Feedback in subgroups	0.7	Medium level where resource exchanges take place at the subgroup level. Feedback in the working subgroup.
Feedback Interpersonal	0.5	Level of interpersonal exchange in the group. Interpersonal feedback.
No Feedback	0.3	Intrapersonal level, where a person contributes resources to the group in isolation, without generating comments.
No exchange	0.1	Resources are not shared.

generating lower impact. It is feasible by adapting vending machines and customizing existing packaging. The novelty is low; it is no more useful than a personal bottle filled from the tap.

From a circularity approach, the complexity of Concept #D is transferred to the system itself because the bottling and purification process (if applicable) is performed at each vending machine, instead of being centralised in a bottling plant, involving additional displacement for maintenance, for instance. But it avoids the distribution of water from the bottling plants, using tap water, obtaining both negative and positive scores in the "Narrowing" strategy. In addition, the reuse of bottles and the extension of their useful life decrease the waste production. Since the function is not only focused on dispensing water, but also on purifying, cleaning and storing bottles, as well as cooling, this results in a vending machine with a more intense operation. This increases the complexity of disassembly, reuse and recycling. For this reason, the concept #D has negative scores with respect to the reference product.

The group #D behaviour structure is influenced by a management style focused on guiding the participants to the achievement of the objective. The interaction and exchange of resources carried out in the group at an interpersonal level, and the difficulty of generating interdependence, are highlighted. The profile of the leader #D achieves greater positivity associated with functionality. The leader encourages the group to obtain results, manages the group with agility, reorganizes the task and reduces ambiguities. The participants are perceived as the most homogeneous in the eco-innovation group activity.

4.2.2. Group #I

Group #I developed the tasks less satisfactorily than the rest. Concept #I was not fully detailed, and the general idea was difficult to understand. Time management was inadequate and there was no agreement and a lack of criteria in the concept definition. Concept #I proposed that the consumer owns an in-house container that is filled regularly by a company and a bottle that is refilled from the tap. The contribution is the reuse of the container, but the objectives are not reached owing to the lack of portability. However, it would be destined for places where the running water is not suitable. The feasibility is low because of the structural changes required in houses and communities. There is no improvement in its utility, and it forces a change in personal water consumption.

From a circularity approach, Concept #I transfers the weight of the system from the bottling plant to the tank delivery system by means of trucks and the tank installation in buildings, which also involves an increase in transport loads and negative scores in all the sub-factors of "Narrowing". As with Concept #D, the concept of "reusable" is introduced, drastically reducing the production of waste and prolonging its useful life. Additionally, the maintenance of the tanks installed in the buildings will involve displacement loads, the use of chemical products for water treatment, etc. The waste management of reusable bottles and water tanks is unequal, due to the need for professional control of the tank uninstallation process. But due to their simplicity, the materials can be recovered, although perhaps with secondary and tertiary recycling.

Table 8
Description of the levels of group activity (Munné, 1985; Palacín and Aiger, 2014, 2017, 2014; Vicente et al., 2006) Distribution of the adjectives of the GAA protocol according to the levels of the Group Activity.

Levels	Description	Pairs of antonym adjectives	
Level 1. Thematic	It represents what the group is doing: objectives, topics of discussion, specific activities, etc. At this level, the group activity is explicit.	Difficult	Easy
		Bored	Fun
		Useless	Productive
		Passive	Active
Level 2. Functional	It shows the instrumental and factual aspect of the group activity, corresponding to the pure interaction.	Messy	Organized
		Tense	Relaxed
		Noisy	Silent
		Closed	Open
Level 3. Cognitive	It focuses on cognitions that participants elaborate about situations, people or things. It focuses on what the participants think, value and reason during the development of the activity.	Uncomfortable	Comfortable
		Unpleasant	Nice
		Confused	Clear
		Harmful	Beneficial
Level 4. Emotional	Describes the set of sensations, emotions and feelings that subjects experience in their intra-group relationships.	Distant	Cozy
		Sad	Cheerful
		Suspicious	Trusting
		Aggressive	Friendly

Table 9
Environmental evaluation of concepts generated in the four creative sessions (D, I, S and C).

	Creativity				Circularity													Group Activity				M$_1$	M$_2$	M$_3$
					Narrowing				Slowing				Closing				TOTAL							
	N	U	F	TOTAL	MU	EU	TL	Total	RR	RU	UI	Total	WG	RC	RQ	Total		Ia	Id	Ex	TOTAL			
#D	0,70	0,50	0,50	**0,175**	−2	−2	1	−3/**0,325**	2	2	2	6/**1000**	1	−1	−1	−1/**0,475**	**0154**	0,090	0010	0,090	**81,0E-06**	27,0E-03	2,18E-06	0,85E-06
#I	0,50	0,30	0,30	**0,045**	−1	−1	−1	−3/**0,325**	1	1	0	2/**0,700**	2	2	1	5/**0,925**	**0210**	0,075	0009	0,075	**50,6E-06**	9,47E-03	0,48E-06	0,29E-06
#S	0,30	0,50	1,00	**0,150**	−1	−1	1	−1/**0,475**	1	0	1	2/**0,700**	1	−1	−1	−1/**0,475**	**0157**	0,210	0035	0,150	**1,10E-03**	23,7E-03	26,1E-06	12,5E-06
#C	0,70	0,70	0,30	**0,147**	−1	−1	1	−1/**0,475**	1	0	1	2/**0,700**	1	−1	−1	−1/**0,475**	**0157**	0,300	0100	0,300	**9,00E-03**	23,2E-03	209E-06	87,8E-06

Leader #I stands out for guiding the group in a people-centred style, their needs and creating a positive work environment. The leader's difficulties were the interaction regulation, the exchange of resources and the lack of facilitation for interdependence. The strong emotionality and spontaneity without restraint generated communication problems. Leader #I obtains the lowest positivity score and with the greatest dispersion in group evaluations. Participants perceive themselves as less functional in the creative process.

4.2.3. Group #S

Group #S executed satisfactorily all the tasks, in detail and on time. The concept fits the proposed brief and responds to all the constraints. Overall, this group satisfied the objectives of all the tasks, but only partially the objective of the design challenge. Concept #S is focused on a bottle to be reused a greater number of times than current bottles. It also addresses factors of use, transport, security, resistance, strength, etc. It uses existing manufacturing processes, so feasibility is high. Conceptually it is not more useful, nor does it have a declared benefit over other bottles.

From a circularity approach, Concept #S proposes a paradigm shift, where each person has their reusable bottle, and the mineral water is transported to the places of consumption. The characteristics of reusable bottles are provided, but the description of how water is stored in places of consumption is not defined. Therefore, this concept would not be equivalent to the reference product. The proposed system improves the efficiency of water transport from the spring, as well as dematerialises the water consumption. But it also complicates the fact of storing water and refilling the bottles, keeping the water in good condition. This concept has been evaluated with negative scores, like Concepts #D and #I, because transporting water in large quantities, and conserving and bottling it at the destination points, has negative implications both in the use of materials and energy, and in aspects related to recycling.

Leader #S emphasizes compliance with rules, regulating interaction due to its sureness and conservative profile. Greater control is exercised in the process and consequently interdependence in the group is inhibited, which minimises spontaneity. The profile of the leader #S obtained average values of positivity, even with the rigor of the work driven by the leader.

4.2.4. Group #C

Group #C manages the results, process and time management adequately. The final result should be better defined because the solution was centred on materials and production. The second task was carried out as suggested but not defined as asked. The results for the third task were focused on achieving the goal following the timetable strictly. Concept #C makes the same contribution as Concept #S. The novelty is low because the proposed product is similar as the existing camelback bottle. Feasibility is low and affected by the need to design a material and manufacturing process. In terms of use, it improves transport due to the adaptation of bottle volume, but user has to carry it continuously.

From a circularity approach, similar to Concept #S, Concept #C proposes a paradigm shift with the proposition of a reusable bottle, but not considering how water is transported and stored in consumption places. So, this concept is not similar to the reference product. For this reason, like the other concepts, Concept #C has been evaluated with negative scores in the use of materials and energy and in aspects related to recycling, because of the negative implications of transporting water in large quantities and conserving and bottling it.

Group #C is the group with the highest positivity of the four groups. The leader with a profile focused on analysis and a critical attitude fosters consensus in decision-making, enhances interaction and the exchange of resources at the group level. The level of group interdependence is the highest of the four groups. The rigorous and logical application in the creative process focuses the group work on the figure of the leader and has an impact on reducing interdependence between

Table 10
Metric to measure the group's activity during its creative development and its positivity values.

	Interaction				Interdependence				Exchange				Positivity Avg. (SD)
	Ph1	Ph2	Ph3	Total	Ph1	Ph2	Ph3	Total	Ph1	Ph2	Ph3	Total	
#D	0,3	1,0	0,3	0,090	0,1	1,0	0,1	0,010	0,3	1,0	0,3	0,090	7,24 (,39)
#I	0,5	0,5	0,3	0,075	0,3	0,3	0,1	0,009	0,5	0,5	0,3	0,075	5,76 (,62)
#S	0,3	1,0	0,7	0,210	0,1	0,7	0,5	0,035	0,3	1,0	0,5	0,150	6,78 (,48)
#C	0,3	1,0	1,0	0,300	0,1	1,0	1,0	0,100	0,3	1,0	1,0	0,300	7,04 (,42)

the group participants. Group #C is the second with the highest positivity and homogeneity in the group's functionality.

5. Interpretation of results and discussion

Based on the results in Tables 9 and 10, Table 11 presents the results for the different options of proposed metric. Comparing the results of M_1 with M_2 and M_3, while #I and #S maintain their fourth and second positions in all the metrics, #D and #C exchange their positions, going from first to third and vice versa.

Solid conclusions cannot be drawn from a single workshop, but clear trends can be identified in line with the group activity literature. Depending on the objectives of the process, the metric will facilitate the choice of leaders, helping to configure groups that maximize the value of the different dimensions. #D leader is direct and gets results from the workshop in the short term. If long-term harmony is needed, groups with an #S leader achieve stability and with a #C leader analysis and depth. On the other hand, a leader must have the ability to regulate his/her management capacities and adapt them to the creative process. The needs during the creative process change depending on how the group works. If there is a clear pattern, a #D profile would be appropriate. If they are doers, then an #S profile would be best. If the group is going to analyse and deepen the concept, this would require a #C profile. However, profile #I facilitate a cordial atmosphere. For this reason, the variable "leader" helps to configure different scenarios through *Interaction*, *Exchange* and *Interdependence* in group management, generating different ways of working. And the metric allows us to control group activity as a unit of analysis.

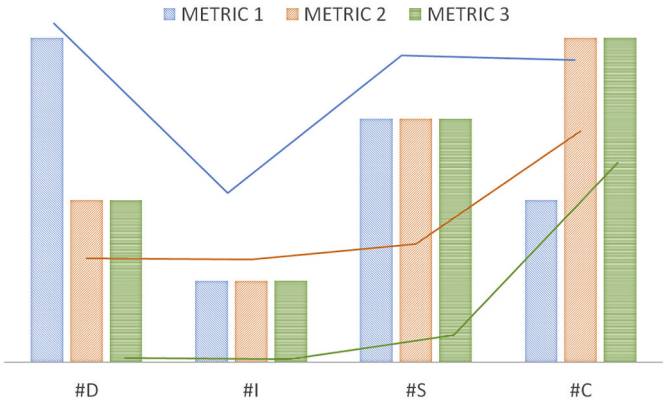
The contribution of this work is to establish a relationship between creativity, circularity and group activity, being a novel contribution to the literature and allowing control over the results and the group activity from a quantitative and intragroup approach. The application of the results and the proposed metric allow us to configure and customize groups oriented to objectives, for specific or stable workgroups. In this regard, the proposed metric can be used at the initial stages of the creative process for the group configuration, or in the middle stages to review some functionality aspect of the creative group and to improve its performance. The results of this work may be of interest to groups that work in the field of sustainability, giving them guidelines to apply the metric and configure their groups, maximizing the creative product and making these groups more sustainable in themselves, since the co-creation in interdisciplinarity and transversality implies sustainability in itself.

Future research will assess the implementation of the following actions: (1) extend the control of the thinking profiles (DISC) to all members of the group, (2) incorporate as independent variables the group composition variables (sex, age, interaction style, etc.), (3) focus on the group management function of the environmental expert to observe the effect on the productivity of the group, (4) apply the proposed model, generating a single team that integrates the four DISC profiles (seeking complementarity in the management of the group) by area of specialization to observe the evolution of the team in the creative process, and (5) apply other group measurement instruments such as the IPA or Bales's SYMLOG (Bales, 1950, 1983) to analyse participation in the group of the different group roles.

6. Conclusions

The assessment of creative processes in eco-innovation requires measurable criteria from innovative, environmental and group performance approaches. This study introduces a novel metric that incorporates the influence of the thinking profiles of leaders of creative

Table 11
Summary of Table 9 with metric values and positions occupied by each concept (D, I, S and C).



	M_1		M_2		M_3	
	SCORE	POSITION	SCORE	POSITION	SCORE	POSITION
#D	27,0E-03	1	2,18E-06	3	0,85E-06	3
#I	9,47E-03	4	0,48E-06	4	0,29E-06	4
#S	23,7E-03	2	26,1E-06	2	12,5E-06	2
#C	23,2E-03	3	209E-06	1	87,8E-06	1

groups, being environmental experts, on the creative product in combination with creativity and circularity dimensions.

The proposed metric allows control of the creative product of the process and managing the creative group at leader and intragroup level. In the creative process, the personality (creative + experts), the procedure and the results are manifested. The metric measures the impact of the three dimensions, evidencing the need for complementary profiles and competencies for leaders and participants.

The metric has different readings that can evaluate different dimensions of the process. M_1 gives us the evaluation of the creative product and circularity. These are measurable and reliable factors that have traditionally been presented. M_2 allows us to evaluate whether the group configuration is appropriate for the established objectives. And M_3 allows us to know the level of functionality of the group itself.

The potential application of this metric focuses on setting up competitive and sustainable creative teams and assessing their performance. Depending on the final objective of the creative process and the nature of the work group, the proposed metric can serve at different stages of the process, from the configuration of the group members to the intermediate supervision of their performance.

CRediT authorship contribution statement

Jorge Sierra-Pérez: Supervision, Conceptualization, Methodology, Funding acquisition, Data curation, Writing – original draft. **Montserrat Aiger Vallés:** Methodology, Data curation, Writing – original draft. **Ignacio López-Forniés:** Methodology, Data curation, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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