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Modeling a cocreative process: The contributions of design and management

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Abstract
This research focuses on the understanding of a team creative process (or co-creative process) by adding design and management inputs to the marketing approach. It proposes and empirically tests a co-creative process based on the three stages of the design thinking method: (1) need definition, (2) idea generation, and (3) solution prototyping. This model also includes the influence of individual variables –empathy, domain-relevant familiarity, and task involvement –at different stages of the co-creative process. The results validate the mediating role of idea generation between need definition and solution prototyping and the influence of the selected individual variables. The predictive validity of the co-creative process has been tested *via* the evaluation of the solution by experts. Several actions are proposed at each stage of the co-creative process to enable organizations to stimulate the creativity of their new product development teams.

Keywords
creativity, creative process, design thinking, individual variables, new product development

Introduction

Many companies encourage the creativity of their new product development teams in order to foster innovation and thus improve their offerings and competitiveness (Bissola et al., 2014). The design thinking method is becoming increasingly popular with companies for innovation and has been highly successful. For example, GE Healthcare's engineer Doug Dietz – having designed an magnetic resonance imaging device and realized that his machine frightened children – used design thinking to make

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the MRI experience less frightening, creating a fairy world from images, smells and sounds, which reduced the use of sedatives from 80% to almost zero. From an academic standpoint, the Marketing Science Institute and its members identified the integration of design thinking into marketing as one of the priority topics for 2016–2018. The challenge for marketing is twofold. On one hand, it involves ensuring that the use of design thinking increases the creative performance of in-house teams and studying the mechanisms that underlie it. On the other hand, it entails identifying and selecting the most successful individuals in terms of the execution of the different stages of a creative process based on design thinking.

The creativity of individuals within internal company teams (or co-creativity) can be defined as "a process that integrates individual, collaborative and collective as well as communal aspects of creativity" (Schmoelz, 2017: 27). Cocreativity differs from individual creativity in that it takes place in teams and within a logic of collaborative innovation (Lynch, 2007, cited in Kauffmann, 2015: 56). However, in marketing, most of the research on creativity focuses on the individual consumer's creativity, that is to say, on the contributions of consumers to the development of new products (Dahl and Moreau, 2002, 2007; Gotteland et al., 2017; Moreau and Engeset, 2016; Salgado and de Barnier, 2016; Vellera and Gavard-Perret, 2016). Despite its interest, cocreativity has been little explored in marketing (Althuizen et al., 2016) and there are few studies that investigate the influence of team members' individual perceptions on collective creative performance (Tu, 2009; Wang et al., 2016). It is within this perspective that we situate ourselves. At a time when marketing is rethinking its methods (Hemonnet-Goujot et al., 2016; Salerno et al., 2013), we are particularly interested in cross-fertilization through work in design – with the method of design thinking and its successive stages – and in management – with the influence of individual variables on the cocreative process.

Arising from the literature on design, design thinking is a human-centered product design method (Brown, 2008) that offers a specific approach for the implementation of the cocreative process. It differs from other product design methods in defining the needs of and uses by consumers, thus accounting for the considerable (and early) interest in design thinking, because the in-depth study of consumers can occupy nearly 50% of the total time allocated to the process (Hemonnet-Goujot et al., 2016). Design thinking is also distinguished by the prototyping of the user experience, allowing, at the end of the process, a better appropriation by users of the proposed solution. In prioritizing the position of consumers, the spirit of design thinking is close to that of marketing and, therefore, brings to marketing a protocol for implementing the cocreative process that is particularly adapted to its needs. Although design thinking has acquired considerable importance within organizations, there are few academic studies on the subject and those that do exist mainly adopt a theoretical perspective (Johansson-Sköldberg et al., 2013).

In management, creativity and its mechanisms have been extensively studied (e.g. Amabile, 1983, 1988; Woodman et al., 1993). The significance of this work for marketing lies mainly in the conceptualization of the process of team creativity and of the specific role played by the characteristics of individuals at each stage of this process. While many studies emphasize the key role of individual variables on the creativity process, there is less research on their influence at an empirical level. Empirical work focuses on individual creativity, particularly the idea generation stage (e.g. Amabile, 1985; Dahl and Moreau, 2002; De Dreu et al., 2008; George and Zhou, 2007; Haller and Courvoisier, 2010; Jafri et al., 2016). Such work does not take into account the influence of individual variables on the stages of a cocreative process. However, Shalley et al. (2004) suggest that "[r]esearch is now needed that focuses on the different stages of creativity and what personal […] characteristics may be most desirable at each stage" (p. 947).

The present study puts forward and tests a conceptualization of the cocreative process based on design thinking, including the distinctive role of individual variables at each stage of the process. The proposed model incorporates Brown's (2008, 2009) three stages of design thinking: (1) definition of needs, (2) generation of ideas, and (3) prototyping the solution. More specifically, our study aims to identify the variables associated with the successive stages of design thinking, to propose reliable and valid measures of these variables, to establish

and test their relationships – including testing mediating effects – and to examine the influence of individual variables on the variables associated with design thinking. To test the robustness of the conceptualization, predictive validity is tested through the evaluation of collective creative performance.

The first contribution of this study is to conceptually clarify the cocreative process based on design thinking and to empirically test the proposed conceptualization. The second contribution is to offer marketing teams a deeper understanding of the mechanisms underlying design thinking, and thus to provide a protocol and recommendations for effective implementation (fertilization of design toward marketing). This contribution is consistent with the shortcomings highlighted by Hemonnet-Goujot et al. (2016: 135), among which the protocol of the design thinking approach has not been sufficiently specified. The third contribution is to identify the participant profiles that are advantageous to include in a team so as to promote creative collective production (fertilization of management toward marketing). This study is situated within a current of research in marketing on the composition of teams involved in the development of new products (Faure, 2001; Gotteland and Haon, 2010; Haon et al., 2009).

Literature, model, and hypotheses

Design and design thinking

Design thinking, stemming from design, is a widespread and well-documented approach to designing new products (Liedtka, 2015; for a review, Micheli et al., 2018). Design thinking describes how the skills of each member of a team can be used to meet the needs of the user. By placing teams within a problem-solving logic, it helps organizations be more creative in designing their products and services. Design thinking is based on a process that involves different stages, varying in number – from three to seven – depending on the authors (Clearly, 2015). Seidel and Fixson (2013) suggest that the approach adopted by Brown (2008, 2009) is the one that is most frequently used. Brown's approach is structured in three successive stages: (1) definition of needs, (2) generation of ideas, and (3) prototyping the solution. Each of these stages is associated with specific concepts – defined below – namely, clarity of users' needs for stage 1; then (1) fluency in idea generation, (2) diversity of ideas generated, and (3) ease of convergence toward a unique solution for stage 2; and finally, the quality of the materialization of the solution for stage 3. The objectives, main techniques, and concepts used for the implementation of a protocol of the cocreative process based on design thinking are detailed in Table 1.

Defining needs and generating ideas

In design thinking, the process begins with a thorough examination of users' needs (Brown, 2008). Luchs and Swan (2011) show that design thinking places special emphasis on the definition of needs stage. For example, Veryzer and Borja de Mozota (2005) describe "user-oriented design" – a method from the design literature that includes design thinking – as "a process that encourages explicit and deep consideration of customer needs" (p. 134). Focusing on the design thinking method for multidisciplinary teams of novices working on a new product concept (a medical tool for surgeons), Seidel and Fixson (2013) compare the approaches used by successful and unsuccessful teams by interviewing them qualitatively and quantitatively. These authors identify the clarity of users' needs as a key concept in the first stage of design thinking and cite a comment by a successful team, for whom this step is clearly apparent:

> [t]he practitioners certainly don't want to admit that they're having difficulty … they would think it would only take a couple of minutes, but if we actually timed them it might take them longer. Even though they said it wasn't much of a need, we felt it was a need, so we continued with it. (Seidel and Fixson, 2013: 25).

Clarity of users' needs is defined as the degree of understanding of users' dissatisfaction and/or unfulfilled wishes.

The generation of ideas begins with "divergence," which involves producing new ideas, without any constraint, without any logical rule, and without any

Table 1. Objectives, techniques, and concepts associated with the stages of a cocreative process based on design thinking.

Stages based on design thinking	Objectives	Examples of techniques used	Related concepts
1. Definition of needs	To study users' dissatisfaction with existing products in order to try to respond to them with a new product or service.	Using techniques to "empathize" with users (i.e. putting oneself in their place), such as ethnographic observation (Patnaik and Becker, 1999) or mental simulation (Dahl et al., 1999).	Clarity of users' needs
2. Generation of ideas	To devise all possible solutions to meet the needs of previously identified users ("divergence" stage); then select the best solution for solving the problem ("convergence" stage).	Use of creative techniques, such as brainstorming (Osborn, 1953) or mind mapping.	(a) Fluency in idea generation; (b) diversity of ideas generated; and (c) ease of convergence on a solution
3. Prototyping of the solution	To create a physical copy of the solution chosen after the convergence phase, whether it is a product, a service, or a combination of both, in order to quickly collect consumer feedback.	Using prototyping techniques, such as user experience scenarios, concept formulation (Brown, 2009; Hemonnet-Goujot et al., 2016), and a composite picture of the user.	Quality of the materialization of the solution

rationality to be respected regarding the ideas emitted by the subject (Vincent, 2012). In line with De Dreu et al. (2008), we consider two indicators of divergence: fluency and diversity. Fluency in idea generation is the ease with which an individual or group produces new ideas. Diversity of ideas generated refers to the extent of ideation, that is to say, the variety of ideas proposed during the generation of ideas stage. It is an indicator of divergent thinking based on individuals' cognitive flexibility, that is, their ability to reorganize ideas by taking into account new information from other team members (Althuizen et al., 2016).

Studies in management (Urban and von Hippel, 1988) and marketing (Dahl et al., 1999) suggest that taking user needs into account in the process of developing new products improves creative production. Treffinger (1995) argues that understanding a problem (e.g. relating to a user's need) is a prerequisite for divergence. The links between clarity of users' needs and fluency in idea generation, on one hand, and between clarity of users' needs and the diversity of ideas produced, on the other hand, can be explained by the fact that a good understanding of users' needs induces positive emotions in a creative team. The activation of positive emotions positively influences fluency in idea generation (Bledow et al., 2013) as well as cognitive flexibility – on which the concept of diversity of ideas is based (De Dreu et al., 2008).

H1. The clarity of users' needs positively influences the fluency in idea generation.

H2. The clarity of users' needs positively influences the diversity of ideas generated.

The diversity of ideas generated during a creative process is based on the cognitive flexibility of team members (Amabile, 1983). The fluency in idea generation is positively correlated with the participants' cognitive flexibility (Ansary et al., 2013). Since cognitive flexibility contributes to the diversity of ideas (Amabile, 1983), we propose, by extension, that there is a positive relationship between the fluency in idea generation and the diversity of ideas generated. In addition, this hypothesis is expected to confirm the results of Nijstad et al. (2002), according to which the more fluid the generation of creative ideas, the greater will be the number of product categories accessible by the members of a creative team (and hence the greater the diversity of categories). The

present study underlines a positive causal relationship between fluency and diversity. If fluency refers to the ease with which participants generate ideas, diversity of ideas refers to the result of this production, especially in terms of the variety of ideas. Thus, the greater participants' ease of generating ideas, the more varied the generation of these ideas should be.

H3. The fluency in idea generation has a positive influence on the diversity of ideas generated.

Ease of convergence refers to the speed with which consensus is reached on the concept (or solution) the team wants to develop. In design thinking, "divergence" precedes "convergence." The sequencing of these stages improves the overall creative process (Seidel and Fixson, 2013). Studies by Mace and Ward (2002) suggest that the quality of implementation of the "activities of idea conception" stage (equivalent to divergence) positively influences the quality of the subsequent stage, namely, the "idea selection and/or refinement" (equivalent to convergence). Once a positive relationship between the two stages of idea generation is postulated, one needs to consider the theoretical elements that might explain this relationship. These elements differ according to whether one considers the fluency in idea generation or the diversity of ideas produced during divergence.

The influence of the fluency in idea generation on ease of convergence can be explained by the existence of positive emotional feelings in the members of the team, thus helping them to agree (or "converge"). The fluency of perceptual processing is likely to trigger a positive feeling which, in turn, positively influences the consumer's decision-making (Graf et al., 2017). By extension, we hypothesize that the positive feeling induced by fluency in idea generation facilitates decision-making within creative teams, leading them to converge more rapidly toward a solution.

H4. The fluency in idea generation has a positive influence on the ease of convergence on a solution.

Diversity of viewpoints can lead to conflict within a team, and thus reduces the ability of members to find agreement on the solution to be implemented in response to a given problem (Bassett-Jones, 2005). Compared to homogeneous teams, teams characterized by heterogeneous thinking find it more difficult to communicate and have more disagreements among their members (Knight et al., 1999). Jehn et al. (1999) show, in particular, that conflicts are present when the heterogeneity of viewpoints concerns a task needing to be carried out. In the convergence stage, it is a matter of finding a creative solution that it is relevant to develop in response to users' needs. In their theory of integrative complexity, Grisé and Gallupe (1999) show that a wide variety of ideas induces cognitive overload, which reduces the team's capacity to select and increases conflict. Hence, we hypothesize that the greater the diversity of ideas generated during the divergence phase, the more difficult it will be to come to agreement (and therefore converge).

H5. The diversity of ideas generated negatively influences the ease of convergence toward a unique solution.

Generation of ideas and prototyping of the solution

The development of concrete solutions is a key step in design thinking. It brings to life the ideas generated by a creative team and allows (1) from a technical standpoint, the feasibility of the proposed solutions to be tested, and (2) from a marketing standpoint, feedback from future users to be collected and areas for improvement to be identified (Liedtka, 2015). This materialization process consists of transforming ideas for testing and refining (Brown and Wyatt, 2010).

The relationship between the diversity of ideas generated and the quality of their materialization is complex. It can be analyzed in two ways. First, a low level of diversity of ideas minimizes disagreements among team members and allows them to work toward a common goal (Leenders et al., 2007). When a group shares a similar vision, a climate of trust develops that enhances its creative performance (Paulus and Brown, 2007). We, therefore, hypothesize that the beneficial effect of a climate of trust will also affect how the creative idea is materialized. Second, a wide diversity of ideas can also stimulate positive discussion among team members and encourages them to defend their respective positions and, as a result, lead to a better way of materializing the concept (Williams et al., 2010). Although the relationship between the diversity of ideas and the quality of their materialization has not yet been tested, Leenders

et al. (2007) detect a curvilinear relationship between the level of disagreement among members of a new product creation team and their performance in terms of creativity. These authors show that a low level of disagreement stimulates creative production, as also does a high level of disagreement. We thus predict a curvilinear relationship between the diversity of ideas and the quality of their materialization.

H6. The diversity of ideas generated has a positive quadratic relationship (U-shaped) with the quality of the materialization of the solution.

Consensus increases a team's performance (Ahearne et al., 2010). In the case of complex tasks, such as a creative process, reaching an agreement calls for discussion among members, who are thereby led to consider the same problem from different angles (Leenders et al., 2007). These exchanges improve the quality of the materialization of their creative ideas. A team's ability to agree on a creative solution should, therefore, positively influence the quality of the materialization of the solution.

H7. The ease of convergence toward a solution positively influences the quality of the materialization of the solution.

Prototyping and testing the solution

The success of a new product or service depends on its capacity to respond to and satisfy users' needs. Consequently, a new product or service undergoes extensive testing before it is marketed, often by experts external to the design team itself. The competitive advantage of a product or service is influenced by its degree of novelty, its originality, and its usefulness (Cooper and Kleinschmidt, 1987). At the end of the cocreative process, the proposed solution is, therefore, tested and its evaluation takes into account these three criteria. Thus, improved formulation of the solution prior to the industrialization process should lead the external experts to evaluate more positively – based on originality, usefulness, and appeal of the solution – the solution proposed by members of the design team.

H8. The quality of the materialization of the solution positively influences its evaluation.

Influence of individual variables on the cocreative process

The role of individual variables on creativity has been extensively investigated, especially in management. Amabile (1983) proposes a synthesis based on three categories: "creativity-relevant skills," "domain-relevant skills," and "task motivation." The advantage of Amabile's (1983) categorization is that it specifies the distinctive role of the categories of individual variables for each stage of the team creativity process, whereas the other research cited focus on individual creativity (of employees or consumers) and usually on the idea generation stage. For each of the three categories, we have attempted to identify the individual variable most likely to influence a cocreative process based on design thinking.

Regarding "creativity-relevant skills," these stem from an individual's ability to complete each stage of the creative process, regardless of the field in which it is applied. This specific category has been extensively investigated, particularly with regards to emotional intelligence (Jafri et al., 2016), thinking by analogy and/or metaphor (Burroughs et al., 2008; Dahl and Moreau, 2002; Gotteland et al., 2017), personality (Haller and Courvoisier, 2010; Shalley et al., 2004), cognitive style (Shalley et al., 2004; Woodman et al., 1993) and mood (De Dreu et al., 2008). In terms of creativity-relevant skills, openness to others (Jeffers, 2009), also known as empathy, appears to be important in design thinking, and is, therefore, investigated in this research. Empathy helps the individual to better understand the needs and wants of users (Brown, 2009). "Domain-relevant skills" refers to "familiarity with and factual knowledge of the domain in question" (Amabile, 1983: 363) and has been investigated from the perspective of familiarity with existing products (Von Hippel, 1986), contextual knowledge (Birdi et al., 2016), and consumer expertise (Gotteland et al., 2017). In design thinking, familiarity with the domain appears to be essential, because it improves the acquisition of new knowledge and identifies where and when creative concepts will benefit the user. Finally, "task motivation" is defined as the value an individual derives when engaging in a specific task, especially in relation to the role of motivation (George and Zhou, 2007) or

motivational factors (Burroughs et al., 2008). Thus, we decided to use involvement in the task, because in organizations, this is one of the most important components of intrinsic motivation (Amabile et al., 1994: 950).

Empathy and the cocreative process. Empathy is an individual's ability to put himself or herself in other people's shoes and understand what they are feeling or thinking. It reflects concern for and understanding of others and their mechanisms of perception and thought. Empathy is viewed as a personality trait or a prosocial motivation (Spalding and Plank, 2007). In design thinking, an individual's empathy should enable him or her to better understand the needs of users and their experiences with the product and service. Moreover, Brown (2009) emphasizes the role of designers' empathy for having intuitions about the user. It seems that empathy promotes the materialization of the concept through a better understanding of the user experience. An individual's empathy should, therefore, favorably influence his or her understanding of users' needs and the materialization of the proposed solution.

H9. Empathy positively influences (1) the clarity of users' needs and (2) the quality of materialization of the solution.

Familiarity with the domain and the cocreative process. An essential component of individual knowledge, familiarity is the sum of information acquired by an individual in a specific area (Alba and Hutchinson, 1987). Woodman et al. (1993) emphasize the critical role of knowledge of the domain on individual creative performance. Prior knowledge of the domain enhances an individual's ability to acquire new knowledge and use it in an original way. In her study of team creativity, Amabile (1983) shows that familiarity with the domain positively influences the prior stage of creative generation (equivalent, in design thinking, to the definition of needs stage), as well as the later stage (equivalent to the solution prototyping stage). The success of the creative process is based on the team's ability to integrate users' thoughts and behaviors into their own ways of thinking. Prior knowledge of the domain allows the team to gain a clearer understanding of users and then to create a concept that matches them better.

H10. The familiarity with the domain positively influences (1) the clarity of users' needs and (2) the quality of materialization of the solution.

Involvement in the task and the cocreative process. Involvement in the task refers to an activity in which the individual is focused on mastering the task (Nicholls, 1984). A person is involved in the task when absorbed by the task on his or her own account, which corresponds to intrinsic motivation (Deci and Ryan, 1985). Crutchfield (1962) distinguishes tasks that involve creativity (i.e. intrinsic motivation related to interesting aspects of the creative activity) from ego-involving tasks (i.e. extrinsic motivation related to obtaining gains, recognition or other advantages unrelated of the task itself). When a creative act is done for itself, it is an involving task whose motivation is intrinsically related to the task. The importance of intrinsic motivations in the creative process is emphasized by Amabile (1983), who suggests that motivation regarding the task is likely have a positive influence on "response generation" (a stage equivalent to the generation of ideas). This influence has been empirically identified (Messmann and Mulder, 2014).

H11. Involvement in the task positively influences (1) the fluency in idea generation, (2) the diversity of ideas, and (3) the ease of convergence toward a unique solution.

An alternative model

In the present study, the question arises as to the utility of the generation of ideas stage. This stage has been presented as critical for creativity (Brown, 2009; Hauser et al., 2006). Is this key role confirmed when the cocreative process is studied as a whole? Do the variables associated with the generation of ideas (step 2) – i.e. the fluency in idea generation, the diversity of ideas, and ease of convergence – play a mediating role between the clarity of users' needs (stage 1) and the prototyping of the solution (stage 3), as suggested by studies deriving from design thinking? In parallel with these questions, the literature on structural equations strongly encourages researchers not to test just one model, but to compare the proposed model with an alternative model (Bollen and

Long, 1992). We will thus compare the proposed model with an alternative model, including a direct relationship between the clarity of users' needs and the quality of materialization. The existence of such a direct relationship would diminish the role-played by the generation of ideas in the cocreative process. This alternative model calls into question the mediating role – between clarity of users' needs and the materialization of the solution – of the fluency in idea generation, the diversity of ideas, and the ease of convergence toward a single solution. In accordance with design thinking (Brown, 2008), we hypothesize that the proposed model will be preferred to the alternative model, thus confirming the mediation hypothesis in relation to the variables associated with the generation of ideas stage.

H12. (1) The fluency in idea generation, (2) the diversity of ideas, and (3) the ease of convergence mediate the relationship between the clarity of users' needs and the quality of the materialization.

Figure 1 summarizes the hypotheses of the proposed model in this research and describes the relationships between the constructs associated with the three stages of the cocreative process based on design thinking. It also details the relationships between these constructs and the individual variables selected, and represents the predictive validity of the cocreative process by linking the quality of the materialization of the solution to its evaluation by an expert in innovation.

Methodology

Procedure

As a team, participants in the creativity seminar were asked to develop a concept to meet the challenge faced by a company, using a cocreative process based on design thinking. Prior to the seminar, teams of four to five people were randomly constituted using Excel's "random" function. At the beginning of the seminar, all participants received a manual precisely describing the instructions to be followed at each stage of the cocreative process. All received the same information and instructions (see protocol in Appendix 1). The seminar took place over a period of 1.5 months, punctuated by three meetings between participants and facilitators, with work to be done between these meetings (i.e. collecting users' needs and prototyping). The sessions were led and the solution evaluated by professors specializing in innovation. These had previously experimented with cocreative processes and undergone training for the implementation of the (timed) stages of the design thinking process and for the evaluation of creative production. For each team, the session leader evaluated the entire team's work (i.e. the formulation and oral presentation of the solution) and gave a score on an evaluation scale to the solution. Each team was required to provide a solution that could be applied within a 6-month delay. The materialization of the solution took the form of a scenario of the user's experience associated with the description of the target user by means of a composite picture and the formulation of the proposed concept (see an example in Appendix 2). This protocol was used successively for two separate collections, one constituting the pretest, the other the main data collection.

Measurement evaluation

To evaluate the quality of the measurement scales, we followed a two-step procedure, as recommended by Steenkamp and van Trijp (1991). The first step involved looking at correlations in order to purge the scales and items with correlations less than 0.30, which were removed. In addition, an exploratory factor analysis (EFA) was carried out, on a pretest sample, to evaluate the quality of the scales we developed (i.e. clarity of users' needs, fluency in idea generation, diversity of ideas, ease of convergence, and quality of the formulation). The second step consisted of a CFA evaluated on the basis of a new sample.

Pretest

Pretest sample. We collected 172 responses from engineering students who had attended a creativity seminar, by means of a questionnaire administered in paper and pencil form. Respondents had an average age of 20.6 years ($SD = 0.86$) and were taking a bachelor's degree specializing in computer science.

Pretest field of study. During the creativity seminar, the teams were in competition to meet the challenge of the kids design company with regard to the

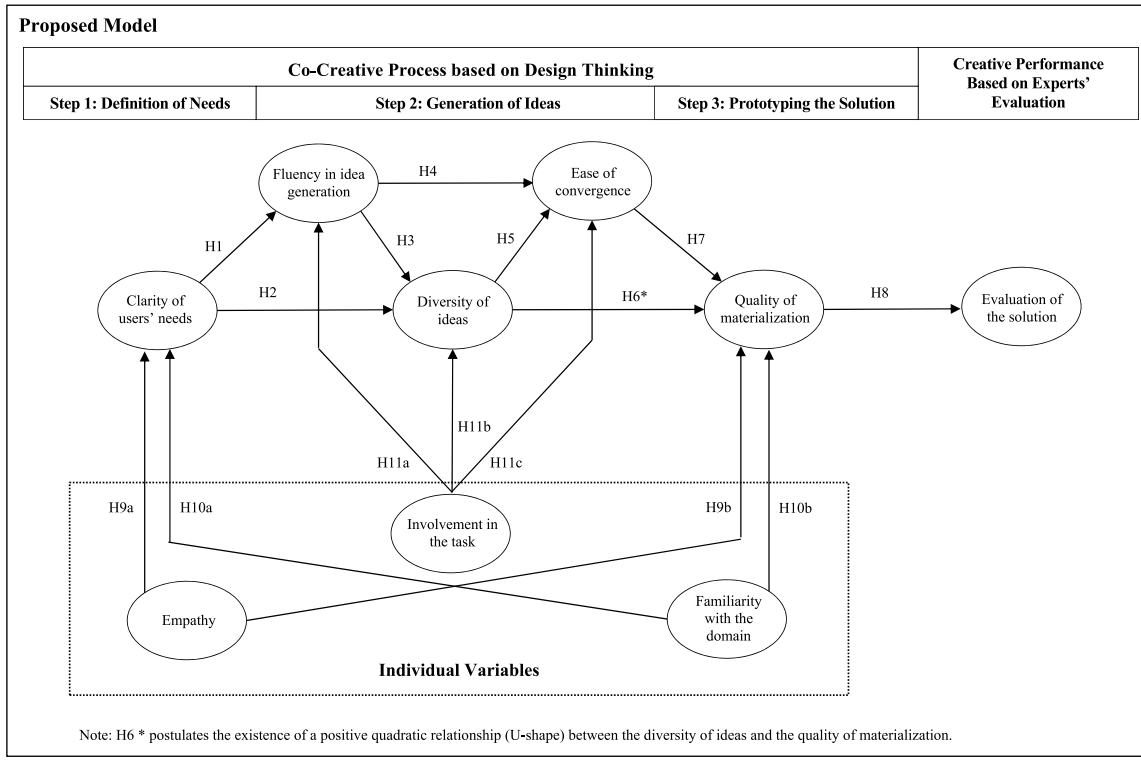

Figure 1. The proposed model.

following issue: "How should we address start-ups and SMEs with an industrial design for innovation, such as the one deployed by Kids Design?" The challenge was broken down into subobjectives (i.e. understanding the needs and issues of start-ups and SMEs in terms of innovation and industrial design; understanding the ecosystem in which start-ups and SMEs operate; devising a new offering adapted to this target; convincing the target and developing its loyalty), to which various constraints were added (i.e. 2 days a week to set up the solution, teams of three people, a budget of €3,000 for a communication campaign). The challenge was presented by one of the cofounders of the company. Interest shown by the IT students in the world of start-ups was an asset. In terms of evaluation, the judges were looking for originality, usefulness, and appeal of the solution.

Construction of measurement scales. To measure the constructs associated with the three stages of design thinking, we constructed original scales inspired by the work of Seidel and Fixson (2013) and developed them following the recommendations of Nunnally (1978) and Churchill (1979). Based on the review of the theoretical and empirical research, we constructed a sample of reflective items for each of the constructs. For the first stage (definition of needs), we proposed a three items 7-point scale for the clarity of users' needs scale, which assesses the degree of understanding of users' needs, as perceived by members of the creativity team. For the second stage (generation of ideas), each constructs were measured using a three items 7-point Likert-type scale. The fluency in idea generation scale reflects the ease and fluidity with which the team came up with ideas for solutions. The diversity of ideas scale assesses the variety and scope of the team's ideas of solutions. The ease of convergence scale measures the facility with which team members successfully felt agree on a unique solution. For the third stage (prototyping of the solution), the quality of the materialization of the

Table 2. Results of the exploratory factor analysis and reliability analysis (pretest sample).

Items	Communalities	Factor 1: Ease of convergence	Factor 2: Diversity of ideas	Factor 3: Fluency in idea generation	Factor 4: Quality of materialization	Factor 5: Clarity of users' needs
CONV2	0.81	0.878				
CONV1	0.78	0.862				
CONV3	0.76	0.858				
DIV3	0.83		0.902			
DIV2	0.83		0.888			
DIV1	0.70		0.774	0.218		
FLU1	0.75			0.838		
FLU2	0.73		0.236	0.813		
FLU3	0.65			0.760		
MAT4	0.71				0.819	
MAT3	0.60				0.741	
MAT2	0.47			0.251	0.601	
MAT1	0.56			0.411	0.527	0.287
CLAR1	0.81					0.876
CLAR2	0.80					0.867
Explained Variance	71.9% in total	15.7%	15.6%	15.6%	13.4%	11.6%
Cronbach's alpha		0.85	0.86	0.80	0.69	0.77

Factor weights less than| .20| are not reported, in order to facilitate reading.

solution was measured using a four items 7-point scale, that evaluates the extent to which the proposed solution was concretely realized.

Results of the pretest. The results are presented in Table 2 and the items wording and coding in Appendix 4. On the basis of the correlation analysis, we removed item 3 from the clarity of users' needs scale (correlation of 0.28 with item 1 and 0.30 with item 2). We then carried out an EFA with Varimax rotation. The results are satisfactory with a total explained variance of 71.9% and a free factorization in five factors corresponding to the five measurement scales. Communalities are greater than 0.50 for each of the items, with the exception of item 2 of the materialization of the solution (MAT2), with 0.47; this item is, however, retained in the analysis. The factor weights are greater than 0.60 for the items associated with the same scale, except item 1 of the materialization of the solution (MAT1), which has a factor weight of 0.53. In accordance with Nunnally's (1978) recommendations, the reliability analysis is satisfactory for an exploratory study, with alpha coefficients greater than 0.70, except for the quality of materialization, with 0.69.

Main study

Sample. As with Dahl et al. (1999), the data collection was carried out among engineering students. The questionnaire was administered though the Qualtrics platform – dedicated to the creation and distribution of online questionnaires – and completed at the end of the creativity process based on design thinking. According to Calder et al. (1981), a sample of students is appropriate for testing a theory, although it has limitations in terms of external validity and generalizing the results. In total, the sample comprised 177 respondents (44 teams), 79.1% male, with an average age of 20.3 ($SD = 0.74$). The respondents were taking a bachelor's degree, specializing in various fields including materials science, biotechnology, electronics, and signal processing. Descriptive statistics for the main sample are presented in Appendix 3.

Field of study. The teams were asked to respond to the challenge of the company Kicklox, worded as follows: "How should engineers be used around the Kicklox platform, the Uber of engineering?" To facilitate the response to the challenge, several sub-objectives were linked to the problem (i.e. create a strong link with these engineers; ensure the engineer's full investment, particularly in the quality of the content; create a secure environment for the customer), together with constraints (i.e. being available 2 days per week to develop the solution; providing the lowest possible acquisition cost per user, or even offering a cash-redeemable solution; taking account of technical feasibility in particular; clearly defining the user/customer being addressed). One of Kicklox's cofounders gave a presentation of the company and the challenge. We chose this theme because of good accessibility to the field of study and the needs of users. The proposed solutions were varied and generally conformed to the objectives and constraints set by the company.

Measurement scales

Scales associated with design thinking. We used the items retained at the end of the pretest (i.e. stage 1: two items for clarity of users' needs, stage 2: three items for fluency in idea generation, diversity of ideas and ease of convergence; stage 3: four items for the quality of the materialization).

Scale for the evaluation of creative performance. Creativity is a complex construct to evaluate and there is no consensus on how it should be done, which has led to the development of various evaluation methods (Blohm et al., 2010). Evaluation of a creative idea can done be according to a criterion or holistically. The criterion approach is often preferred and different criteria are proposed, such as novelty, usefulness or ease of implementation. One, two or more criteria are used depending on the study (for a summary: Blohm et al., 2010). Evaluators may, however, find it difficult to disaggregate their assessment, which may lead to less satisfactory results than with a holistic approach, based on aggregate feeling (Kornish and Hutchison-Krupat, 2017). In general, the two approaches largely converge, and the holistic approach is a reliable option because it calls for fewer cognitive resources (Magnusson et al., 2014). The holistic approach can either be based primarily on the criterion of novelty (Dean et al., 2006), or may include others, such as useful ideas (Gong et al., 2009). There are, thus, intermediate approaches for the overall evaluation of an idea according to various criteria (Dean et al., 2006), and this approach that we have adopted is shared by other authors working on creativity (Gong et al., 2013). The scale used for the evaluation the solution is a three items 7-point semantic differentiator scale, which was completed for each team by the facilitator after the cocreative process. Evaluation of a team's creative performance by the direct supervisor is widely used and accepted in the innovation literature (Shin and Zhou, 2007). The three items selected and their wordings were based on the criteria, proposed by Dahl et al. (1999), of originality, usefulness, and appeal of the solution.

Scales for individual variables. For empathy, we used a three items 7-point Likert-type scale adapted from Wakabayashi et al. (2006). This scale has the advantage of taking into account the ability to understand others, to put oneself easily in their place, and to identify their emotions. Familiarity with the domain was measured by the two items 7-point Likert-type scale developed by Machleit et al. (1993) and subsequently used by Kent and Allen (1994). For involvement in the task, we used a two items 7-point Likert-type scale adapted from Martin et al. (2009), which measures the degree to which participants are engaged in and focused on the creative task

Results

Measurement test

We carried out a CFA evaluated on the basis of the indices recommended by Hu and Bentler (1998). The CFA allowed us to test the measurement model, as well as evaluate the convergent and discriminant validity of each construct. The results of the CFA, presented in Appendix 4, confirm the fit of the measurement model to the data collected: $\chi^2/239 = 1.5$, root mean square error approximation (RMSEA) = 0.055, comparative fit index (CFI) = 0.938, standardized root mean square

Table 3. Reliability, convergent validity, and discriminant validity.

Constructs	A.V.E.	CLAR	FLU	DIV	CONV	MAT	EVAL	EMP	FAM	IMPL
CLAR	**.61**	*.76*								
FLU	**.58**	.189	*.78*							
DIV	**.61**	.187	.246	*.82*						
CONV	**.67**	.159	.264	.045	*.85*					
MAT	**.52**	.208	.242	.124	.381	*.79*				
EVAL	**.78**	.032	.004	.003	.019	.026	*.91*			
EMP	**.62**	.125	.035	.064	.000	.044	.067	*.82*		
FAM	**.61**	.120	.054	.043	.056	.121	.010	.046	*.75*	
IMPL	**.68**	.115	.052	.158	.150	.171	.002	.073	.125	*.80*

The average extracted variance by construct is presented in the second column and is in bold. The alpha coefficients are presented in the diagonal and are italicized. The squares of the correlations between constructs are presented in the lower triangle.

residual (SRMR) = 0.054. In addition, all the estimated parameters have significance lower than 0.001, thus confirming the relevance of each of the variables included in the model.

The analysis of reliability, convergent validity and discriminant validity shows the satisfactory results of each of the constructs (Table 3). *Reliability* is satisfactory, with values greater than 0.70 for each construct, consistently with the recommendations of Nunnally (1978). In agreement with Fornell and Larcker (1981), the *convergent validity* of each of the constructs is confirmed with extracted variance values greater than 0.50, and the *discriminant validity* is confirmed since the variance extracted from each construct is greater than their squared correlation. Thus, all the constructs can be used for hypothesis testing.

In order to assess the risks associated with the potential existence of a common underlying factor that explains our results, we tested for the method bias effect. For this, we carried out two types of analysis: (1) the Harman single factor test using an EFA and (2) common method factor test using a CFA. First for the EFA, all the items of nine constructs of the proposed model were included in the analysis; the results show the existence of nine distinct factors for which the items related to a construct converge accordingly on one unique factor. In addition, the total variance explained for a nine-factor factorization is 77.4%, against 25.8% for a single factor. This first test, therefore, shows that there is no method effect. Second, the CFA confirms these conclusions, since the variance extracted for the common method factor is 4.3% – below the average of the method effect found in marketing, which is 15.8% in average (Cote and Buckley, 1987).

Testing the proposed model

The proposed model – H1 to H11 – was tested at one time using structural equations modeling following the maximum likelihood method using IBM-SPSS-AMOS 18 software. For the analysis of the results, we used the indices and quality standards recommended by Hu and Bentler (1998) and those proposed by Iacobucci (2010) for SRMR. The proposed structure model presents satisfactory results: $\chi^2/281 = 1.57$; RMSEA = 0.057; CFI = 0.924; SRMR = 0.076. Table 4 and the figure in Appendix 5 present the test results of the proposed model, including adequacy measures and hypothesis testing.

For the relationships between the definition of needs (stage 1) and the generation of ideas (stage 2), although the clarity of users' needs significantly and positively influences fluency in idea generation (H1: $\beta = 0.43$, $p = 0.000$), it has no significant influence on the diversity of ideas (H2: $\beta = 0.18$, $p = 0.061$). Thus, H1 is supported, but not H2.

During the generation of ideas (stage 2), fluency in idea generation has a significant and positive influence on the diversity of ideas (H3: $\beta = 0.36$, $p = 0.000$) and the ease of convergence toward a solution (H4: $\beta = 0.56$, $p = 0.000$). In contrast, the diversity of ideas has no significant

influence on the ease of convergence toward a solution (H5: $\beta = -0.20$, $p = 0.059$). H3 and H4 are supported, while H5 is not.

Regarding the relationships between the generation of ideas (stage 2) and the prototyping of the solution (stage 3), the results show that the diversity of ideas has a significant and positive quadratic relationship on the quality of materialization (H6: $\beta = 0.15$, $p = 0.021$). Similarly, the ease of convergence toward a solution has a significant and positive influence on the quality of the materialization of the solution (H7: $\beta = 0.54$, $p = 0.000$). H6 and H7 are supported.

For testing H6, we use the Johnson–Neyman technique adapted to quadratic effects. Beforehand, we created an index (i.e. calculating the average of items) for the diversity of ideas and the quality of materialization. Figure 2 models the polynomial regression ($y = \beta_0 + \beta_1 \times x + \beta_2 \times x^2$, where y is the quality of the materialization and x the diversity of the ideas) and shows that the relationship between the diversity of ideas and the quality of the materialization is convex in form. To interpret the quadratic term, we use the technique proposed by Miller et al. (2013), which gives the Johnson–Neyman graph the simple slope of a quadratic effect (Figure 3) and whose main advantage is that it can identify the exact extent of the values of a variable for which the quadratic relationship is significant (Andel et al., 2014). In this particular case, the significance of the slope of the diversity of ideas on the quality of materialization is examined at each point (from 1.33 to 7) of the average of the diversity of ideas – a variable previously mean-centered. For values of diversity of ideas less than 4.33, the confidence interval includes the value 0, that is, the simple slope of the diversity of ideas is not significant. In contrast, it is significant for values of 4.33 to 7 of the diversity of ideas, since the confidence interval does not include the value 0. These results allow us to detail the quadratic relationship, since the positive effect of diversity ideas on the quality of the materialization occurs only for individuals with moderate to high levels of diversity of ideas, but not for those with low levels ($M_{\text{Diversity}} = 4.92$; $SD = 1.07$).

Regarding the relationship between the prototyping of the solution (stage 3) and the evaluation of the solution, the results show that the quality of the materialization of the solution significantly and positively influences the evaluation of the solution (H8: $\beta = 0.18$; $p = 0.030$). H8 is supported.

For empathy, the results show that empathy significantly and positively influences both the clarity of users' needs (H9a: $\beta = 0.30$, $p = .001$) and the quality of materialization (H9b, $\beta = 0.15$, $p = 0.037$). H9 is, therefore, supported.

Concerning the familiarity with the domain, the results show that familiarity with the domain has a significant and positive influence on the clarity of users' needs (H10a: $\beta = 0.31$, $p = 0.002$), whereas it has no significant effect on the quality of materialization (H10b, $\beta = 0.14$, $p = 0.077$). H10 is, therefore, partially supported.

With regard to the role of the involvement in the task, the results show that involvement positively influences the diversity of ideas (H11b, $\beta = 0.27$, $p = 0.002$) and the ease of convergence toward a solution (H11c: $\beta = 0.34$, $p = 0.000$). But involvement in the task does not influence the fluency in idea generation (H11a: $\beta = 0.10$, $p = 0.244$). H11 is, therefore, partially supported.

Testing the alternative model

To set up the alternative model, we add to the proposed model a direct causal relationship between the clarity of users' needs and the quality of materialization. The alternative model gives acceptable results (Table 4): $\chi^2/280 = 1.57$; RMSEA = 0.057; CFI = 0.924; and SRMR = 0.076. With a χ^2 difference of 2.15 for one degree of freedom, the χ^2 comparison test between the two models is nonsignificant ($p = 0.142$). In addition, the clarity of users' needs does not have a significant influence on the quality of the materialization ($\beta = 0.15$, $p = 0.113$). Following the principle of parsimony, the proposed model is thus preferred to the alternative model.

To test the mediating role of the fluency in idea generation, the diversity of ideas and the ease of convergence, we followed the recommendations of Zhao et al. (2010) and those of Preacher and Hayes (2004). We used the bootstrap test for the indirect effects using structural equations modeling. The results show that the indirect effect of clarity of users' needs on evaluation of the solution is significant and positive ($b = 0.03$, $p = 0.007$) with a 95% confidence interval (b between .01 and .07), which excludes the value

Table 4. Results of the test of the proposed model and the competitive model.

				Alternative model				Competitive model			
				Partial standardization	σ	*t* test	*p* value	Partial standardization	σ	*t* test	*p* value
Cocreative process based on design thinking											
Definition of needs and ideas' generation of ideas											
H1	Clarity of users' needs	→	Fluency in idea generation	0.43	0.09	4.32	0.000	0.43	0.091	4.35	0.000
H2	Clarity of users' needs	→	Diversity of ideas	0.18	0.086	1.87	0.061	0.18	0.088	1.84	0.066
	Clarity of users' needs	→	Quality of materialization	–	–	–	–	0.15	0.091	1.58	0.113
Generation of ideas											
H3	Fluency in idea generation	→	Diversity of ideas	0.36	0.094	3.74	0.000	0.36	0.093	3.72	0.000
H4	Fluency in idea generation	→	Ease of convergence	0.56	0.111	5.36	0.000	0.56	0.110	5.32	0.000
H5	Diversity of ideas	→	Ease of convergence	−0.20	0.114	−1.89	0.059	−0.19	0.114	−1.86	0.062
Generation of ideas and prototyping of the solution											
	Diversity of ideas	→	Quality of materialization	0.21	0.084	2.81	0.005	0.18	0.088	2.19	0.029
H6	Diversity of ideas × Diversity of ideas	→	Quality of materialization	0.15	0.039	2.32	0.021	0.16	0.038	2.55	0.011
H7	Ease of convergence	→	Quality of materialization	0.54	0.081	6.68	0.000	0.51	0.081	6.34	0.000
Prototyping of the solution and evaluation of experts											
H8	Quality of materialization	→	Evaluation of the solution	0.18	0.082	2.17	0.030	0.18	0.083	2.17	0.030
Influence of individual variables											
Empathy and cocreative process											
H9a	Empathy	→	Clarity of users' needs	0.30	0.096	3.19	0.001	0.30	0.095	3.18	0.001
H9b	Empathy	→	Quality of materialization	0.15	0.073	2.09	0.037	0.12	0.075	1.54	0.124
Familiarity with the domain and cocreative process											
H10a	Familiarity with the domain	→	Clarity of users' needs	0.31	0.102	3.08	0.002	0.31	0.100	3.01	0.003
H10b	Familiarity with the domain	→	Quality of materialization	0.14	0.077	1.77	0.077	0.10	0.079	1.26	0.207
Involvement in the task and cocreative process											
H11a	Involvement in the task	→	Fluency in idea generation	0.10	0.078	1.17	0.244	0.10	0.078	1.14	0.253
H11b	Involvement in the task	→	Diversity of ideas	0.27	0.074	3.12	0.002	0.27	0.074	3.11	0.002
H11c	Involvement in the task	→	Ease of convergence	0.34	0.088	3.62	0.000	0.34	0.088	3.62	0.000
Goodness-of-fit measures				χ^2/df = 441.6/281 (1.57) RMSEA = 0.057 CFI = 0.924 SRMR = 0.076				χ^2/df = 439.4/280 (1.57) RMSEA = 0.057 CFI = 0.924 SRMR = 0.076			

RMSEA: root mean square error approximation; CFI: comparative fit index; SRMR: standardized root mean square residual.

zero. Moreover, with the exception of the indirect effect of the diversity of ideas on evaluation of the solution, which is insignificant, all the model's indirect effects are significant. Table 5 summarizes the results. H12 is, therefore, partially supported.

Discussion

Theoretical implications

The results empirically confirm our conceptualization of the cocreative process based on design thinking including the distinctive role of individual variables at each stage. Most of the hypotheses have been confirmed, as well as the fact that each stage of the process influences the next one. The measurement scales for the constructs associated with design thinking have been developed and validated. Predictive validity is also confirmed, with a favorable influence on the evaluation of the solution by experts.

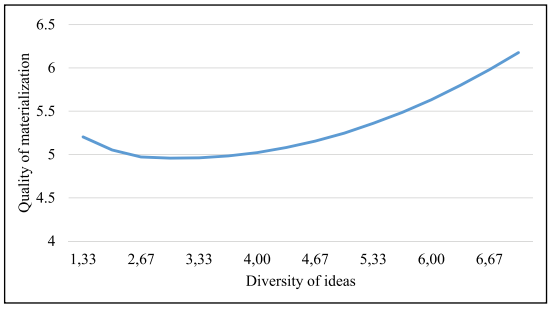

Figure 2. Plot of the quadratic relationship between the diversity of ideas and the quality of materialization.

The study of the mechanisms underlying the cocreative process reveals that the clearer users' needs are for the creative team, the easier it is for them to produce ideas. This fluency in the generation of ideas also improves the generation of various ideas. On the other hand, the diversity of ideas is not helped by a better understanding of needs. The clarity of users' needs has only an indirect influence on the diversity of ideas. The underlying mechanism is that clarity of users' needs leads to greater fluency in the generation of ideas, which in turn increases the diversity of ideas generated. This definition of needs stage is an essential prerequisite for the successful generation of ideas (Brown, 2009). The relationships between the diversity of ideas and the ease of convergence toward a solution need to be analyzed more deeply. While the diversity of ideas can negatively influence the ease of convergence, because of conflicts within the team (Bassett-Jones, 2005), it can also act positively. Indeed, the diversity of a set of ideas generates emulation within a group, which then facilitates the emergence of agreement (and, therefore, convergence) with regard to ideas (Paulus and Brown, 2007). These two opposing influences could explain the statistical nonsignificance of the relationship between the diversity of ideas and the ease of convergence.

At the generation of ideas stage, the fluency of idea generation and the diversity of ideas have an opposing effect on the ease of converging to a

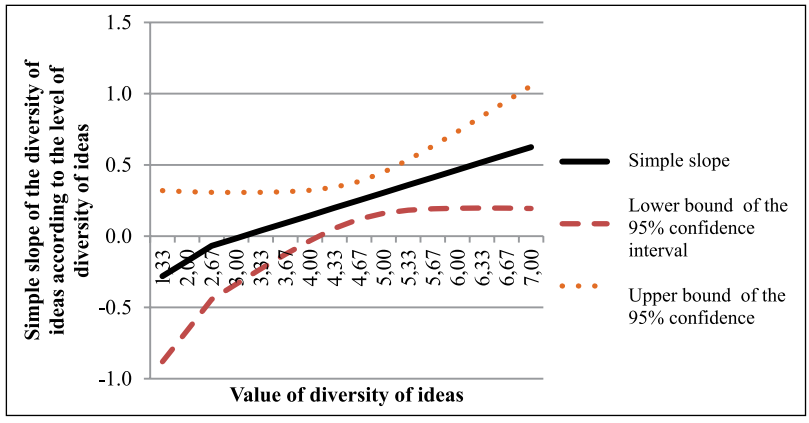

Figure 3. Graph of Johnson–Neyman of the simple slope of a quadratic effect.

Table 5. Results of the test of indirect effects.

Indirect paths	Standardized parameters			
	Values	Lower bounds	Upper bounds	p value
CLAR→FLU→DIV	0.16	0.08	0.29	0.005
FLU→DIV→CONV	−0.07	−0.21	−0.01	0.038
CLAR→FLU→DIV→CONV	0.17	0.08	0.30	0.013
DIV→CONV→MAT	−0.11	−0.24	−0.01	0.044
FLU→DIV→CONV→MAT	0.34	0.21	0.45	0.013
CLAR→FLU→DIV→CONV→MAT	0.17	0.10	0.29	0.005
CONV→MAT→EVAL	0.10	0.03	0.19	0.013
DIV→CONV→MAT→EVAL	0.02	−0.00	0.08	0.154
DIV*DIV→CONV→MAT→EVAL	0.03	0.00	0.09	0.086
FLU→DIV→CONV→MAT→EVAL	0.06	0.02	0.12	0.008
CLAR→FLU→DIV→CONV→MAT→EVAL	0.03	0.01	0.07	0.007

single solution. While fluency improves ease of convergence, a wide variety of ideas produced makes it more difficult to obtain a consensus. At the prototyping stage, a moderate to large diversity of ideas improves the quality of the materialization, thus revealing its utility during the cocreative process. This finding is consistent with studies in management and underlines the value of a wide diversity in creative teams. In addition, the quality of the materialization is improved when convergence to a single solution has been easy.

Consistently with Amabile's (1983) research, our findings show empirically that each individual variables studied have a specific influence on the stages of the cocreative process. While empathy is presented as an important characteristic in the implementation of design thinking (Brown and Katz, 2011), our results confirm that it plays a key role in the stages of defining needs and prototyping the solution. For familiarity with the domain, the results are mixed: it improves the understanding of the needs, but not the quality of the materialization. Seidel and Fixson (2013), who also use student teams, consider them to be novices (vs experts). Because familiarity generally increases expertise, we can assume that, given the nature of the sample, we have rather moderate levels of familiarity with the domain. This characteristic could explain the lack of effect of familiarity on the materialization of the solution. Involvement in the task positively influences the idea generation stage, since being involved in the task facilitates the production of varied ideas and the ability to converge toward a solution. On the other hand, it has no effect on the fluency in idea generation. This lack of effect could be explained by the fact that a high level of motivation may slow down the generation of ideas by inducing self-censorship on the part of the individual and hence not expressing his or her own opinion when among colleagues imagined to be in disagreement with it. There are various reasons for self-censorship within a group, such as avoiding conflict, not wishing to cause offense, fear of stating an opinion that might be perceived as not conforming to certain standards, or attempting to control one's image (Roberts and Nason, 2011). Because self-censorship is detrimental to the creativity of a group (Williams, 2002), it may be supposed that that highly involved individuals censor themselves and that, as a result, the fluency in idea generation is reduced.

Managerial implications

Our findings show that implementation of a cocreative process based on design thinking improves creative production by teams. Thus, it is very much in the interest of companies to support their new product design teams at every stage of the process. Our work offers professionals three main contributions: individual criteria for identifying and selecting people to join a creative team; the design thinking protocol to be implemented by the

company for producing a creative result; and action levers at each stage of the procedure and the linkage between them.

Regarding the selection criteria, it is not always easy for companies to decide which individuals should participate in the creative process leading to the design of new products. Our research suggests that the team should include people with a high level of empathy (measurable through the three items used in this study) and should have one or more members who are familiar with the domain (internal or external to the organization), so as to increase the relevance and originality of the proposed concepts. It also seems to be a good idea to include people who are motivated by the idea of participating in the process, as their strong involvement gives impetus to the idea generation phase, by contributing to the diversity of ideas and finding the resources to make the often difficult decision as to which concept to develop. In addition, the involvement of team members can be enhanced by the facilitator during the generation of ideas, in particular by adding a ludic dimension to the creative process, since enjoyment augments intrinsic motivation (Brown, 2008). Organizing a seminar outside the company or using a creative platform can also stimulate the participants' involvement.

Our research offers companies a detailed description of the protocol to follow – including its stages, objectives, and the techniques used – for developing a cocreative process based on design thinking. This approach can be implemented in six sequential stages: (1) an upstream stage for framing the challenge and selecting the members of the creativity team; (2) a stage for launching the creativity workshop, including presentation to the team of the challenge and the resources available; (3) a needs definition stage to clarify the contours of the challenge, to seek information on the possible ways that the challenge can be approached and to find examples from other sectors, but also to question and observe users *in situ*, then as a team to review this information in order to identify difficulties and the needs and wishes of stakeholders; (4) an idea generation stage, first to allow ideas to be generated through brainstorming, for example, then to select the best ideas so as to begin elaborating the first concepts, choosing the solution to adopt on the basis of a vote, and finally exploring ways of improving the solution; (5) a prototyping phase for consolidating the solution by putting forward ideas to correct any weaknesses, and for concretely articulating the solution by means of the user's composite portrait, picturing the user's experience, and formulation of the concept; and (6) an evaluation and testing stage with experts in the domain and potential users.

This research also offers companies a better understanding of action levers – clarity of users' needs, fluency in idea generation, diversity of ideas, ease of convergence, quality of materialization – and their linkage, for each stage of the co-creative process. Companies should recognize the importance of clarity of users' needs as a critical prerequisite for creative production. For users' needs to be clear for the team, it is appropriate to choose team members who display empathy and are familiar with the domain. It is also advisable to train teams to find out what users' needs are – for this, several techniques are possible, such as individual interviews, group interviews, or observation of users in situ. Clarity of users' needs is important in the creative process because it positively influences the fluency in idea generation, which, in turn, improves the diversity of ideas produced and the team's ability to converge on a single solution. Thus, the idea generation stage is improved by having a good knowledge of users' needs, as well as there being a high degree of degree of involvement on the part of team members. The company should, therefore, carefully choose the workshop facilitator, so that he or she is able to energize the team in this stage, which requires a major cognitive effort from the participants. Finally, the company should be attentive to the quality of the materialization, which is directly related to the perception of the creative production by experts. This means providing participants with all the time and equipment needed (e.g. Lego, modeling clay, programmable Arduino boards) to make the prototype as comprehensible as possible.

Limitations and future research

The study took place in a natural environment (i.e. in a real creativity workshop), for which external validity is stronger. On the other hand, this noncontrolled

environment may alter the internal validity of the results, and constitutes one of the limitations of this study with regard to two aspects of the data collection: (1) the self-assessed nature of most measures and (2) the evaluation of creative performance by an expert. These two aspects both rely on evaluations carried out by individuals involved in the creativity process, and in this respect constitute the main limitation of the study. Nevertheless, the literature contains a number of arguments that provide some reassurance as to the validity of the chosen approach and, consequently, its findings.

With regard to the self-assessed measures, Conway and Lance (2010) consider that they are appropriate for certain types of measurement, especially in relation to creativity. Shalley et al. (2009) choose a self-assessed measure of creativity, on the grounds that employees are best placed to evaluate their own creativity. The main reason given is that self-assessed measures are seen as more nuanced than those made by observers. Although there is a possibility of bias, Axtell et al. (2000) point out the strong correlation between measures reported by participants, on the one hand, and by their supervisors, on the other. This finding suggests a form of internal validity, provided that the supervisor is in a position to evaluate the creative performance of his or her team.

Regarding the choice of evaluator for creative production, various questions arise, including those pertaining to the number and quality of the evaluators, with some studies using several evaluators to judge the creativity of the ideas (Dean et al., 2006). The number of evaluators used varies according to the degree of expertise of those assessed: more will be needed with consumer-assessors than with expert assessors (Althuizen et al., 2016). In the case of multiple evaluators, it is necessary to check the consistency of assessments from one evaluator with another using indicators such as Cronbach's alpha (Dean et al., 2006), interclass correlations (Blohm et al., 2010), or Krippendorff's alpha (Poetz and Schreier, 2012). The match between assessors may sometimes be problematic and can be poor in the absence of prior calibration (Magnusson et al., 2014). Other studies, conversely, focus on evaluating a team's creative performance by a single person. Evaluation of this kind is widely used and accepted in the innovation literature (Shin and Zhou, 2007). In studies on team creativity, evaluation is done by the team's manager (or direct supervisor; Gong et al., 2013). Shin and Zhou (2007) show the absence of a response bias in evaluation by supervisors, a finding that is rather reassuring with regard to the validity of creative evaluation by the supervisor.

The way in which the creative solution should be evaluated, and in particular the role of the evaluator(s), is an important area of discussion. For future research, and to enhance internal validity, we suggest incorporating a nonexpert observer into the creativity team, who follows the participants' actions during the seminar and evaluates their creative performance. Doing so will help ensure consistency of assessments between different sources (i.e. observers, assessors and teams). Another possibility would be to have self-evaluation linked to evaluation by peers, which would allow any convergence or divergence of perception and evaluation to be perceived. It should also be checked that judges assess the process and the creative idea separately.

The size and nature of the samples are also a limitation. However, the sample size is acceptable compared with other studies on creativity and bearing in mind the difficulty of collecting this type of data about a group process spanning more than a month and following a very strict implementation procedure. Research on creativity in marketing often makes use of student samples (e.g. Seidel and Fixson, 2013). Although acceptable for testing a theory, the use of this type of sample involves restrictions on external validity and the generalizability of the findings (Calder et al., 1981). To detect the influence of higher levels of familiarity on the stages of design thinking and its evaluation, expert individuals should be included in the sample. Experts use different modes of reasoning than novices, leading to results of greater or lesser effectiveness depending on the creative method used (Gotteland et al., 2017). However, a sample of students can be useful because they bring a fresh eye to the problems to be solved and are easily able to question users, which is a major advantage in design thinking. Moreover, companies are not mistaken in this respect, because creativity seminars

are increasingly held in universities and engineering and business schools. It seems that students bring real added value to companies in terms of new ideas.

Regarding the administration of the questionnaire, we carried out all the measurements at the end of the cocreative process. Doing this gives rise to biases, mainly with regard to measuring familiarity with the domain, which ought to be measured upstream of the creative process. Indeed, the creativity process tends to increases the knowledge acquired by the participants, and thus enhances their familiarity with the domain. In future work, it will be important to ensure that familiarity is measured early in the process. To distinguish the intrinsic and extrinsic motivations of participants, a measurement scale such as the work preference inventory (Amabile et al., 1994) should be used.

This study has focused on the mechanisms that lead to the cocreation of new concepts. Assessors evaluated the overall quality of the creative production by considering the three criteria of originality, usefulness, and appeal of the solution. These criteria could be considered separately – which would be necessary in the event of a negative correlation between them (Poetz and Schreier, 2012). But this was not the case with our measurement, which has good convergent validity. Other measures are also possible, and future research could include criteria such as ease of implementation (Althuizen et al., 2016).

Conclusion

Because of the high stakes involved in the question of innovation, marketing is currently experiencing a renewal of its methods for developing new products. To us, cross-fertilization seems to be an answer particularly suited to this period of changing practices. We thus sought to contribute to this dynamic by taking into account studies in design, using the method of design thinking and its successive stages, and in management, by studying the influence of individual variables on the variables associated with these different stages. Our findings show the value of design thinking for enhancing the creative performance of a new product design team. They also provide tools for its implementation and a deeper understanding of the mechanisms underlying the linkage of the successive stages of design thinking, and open up new research perspectives for the scientific community.

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Appendix 1. The Protocol used for implementing the cocreative process based on design thinking.

SEMINAR LAUNCH & GUIDELINES [Day 1]
- Presentation by the facilitator of the aims and organization of the seminar
- Presentation by the project initiator of the challenge and its objectives and constraints

↓

STAGE 1: DEFINITION OF NEEDS

Clarifying the challenge and seeking inspiration [Day 1]
- Familiarization with the company and the challenge (reading of a use study)
- Clarification of the challenge (what? for whom? why?)
- Search for information on the possible resolution axes identified by the project initiator
- Search for inspiring projects to meet the challenge and sharing these projects with the team

Defining the needs of users/customers [between Day 1 and Day 30]
- Preparation of interviews and observations. Putting oneself in the place of users
- Survey, observation and analysis of the difficulties, needs and wishes of stakeholders
- Identification of contradictions, tensions and surprises related to the challenge

Disseminating and sharing information [Day 30]
- Sharing with the team information collected that is useful for resolving the challenge
- Identification of information pathways constituting axes for resolving the challenge
- Preparation of questions for the brainstorming.

STAGE 2. GENERATION OF IDEAS

Generating ideas and devising the first solutions [Day 30]
- Production of ideas through brainstorming with the instruction "no filtering, no judgment"
- Selection of preferred ideas
- Elaborating the first solutions on the basis of the preferred ideas

Converging toward a solution [Day 30]
- Selection of the solution to be used on the basis of a vote
- Exploration of new possibilities for improving the solution with the "what if?" technique

STAGE 3. PROTOTYPING THE SOLUTION

Consolidating the solution [Day 30]
- Consolidation of the solution adopted with the "angels and demons" technique. The demons emphasize the weaknesses, inconsistencies, difficulty of implementation and needless functions. The angels suggest possible ways of overcoming the weaknesses.

Materialization of the solution [between Day 30 and Day 45]
- Description of the composite picture of the user (Who is he? What is his interest in the solution?)
- Portraying the user experience in the form of a storyboard (history/chronology)
- Formalization of the solution (What it is? To whom is it addressed? What purpose does it serve? How will it be used?)
- Preparation of the presentation (work on the argument and coaching)

↓

EVALUATION OF CREATIVE PERFORMANCE WITH EXPERTS [Day 45]
- Presentation of the solution and its material expression with experts

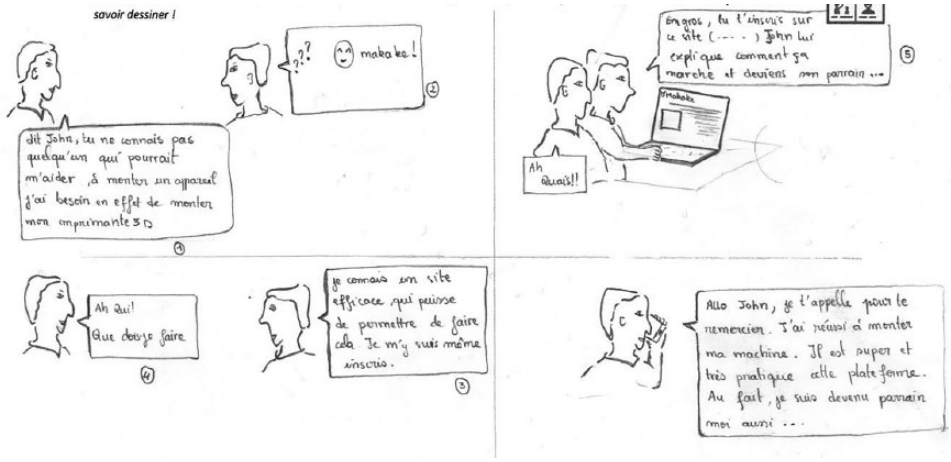
From stage 1, the participants are the main actors of the seminar. They have a detailed manual and a supervisor trained in the method of design thinking to guide them in the cocreative process.

Appendix 2. Example of materialization of the solution.

COLLECTING USER NEEDS

Publicizing the platform through advertisements, forums, and trade fairs for presenting the project.
Having an advisor at the time of registration so as to not feel lost.
Hearing about it at [engineering] school and setting up partnerships with Junior Enterprise.
Help finding an internship, including in the final year of engineering school.
Setting up a control system with ratings of members to instill trust.
Start by reviewing the name: Makake[a] is not serious.

STORYBOARD OF THE USER EXPERIENCE



DESCRIPTION OF THE TARGETED USER though a composite portrait

His name and his characteristics. John is 24 years old and has a diploma in electrical engineering and industrial computer science. He does temporary work as an automation engineer in an SME. He is a typical modern young man: single, sports player, gamer. So he is likely to be a good "maker."

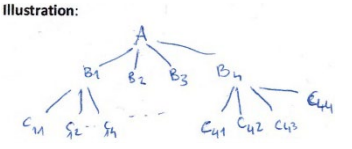
The benefits of your solution for the target user. (1) In this unstable situation, John is looking for autonomy and dislikes hierarchies. (2) He will enjoy the benefits of sponsorship, which will give him more visibility and allow him in the short term to benefit from access to a project.

FORMULATION OF THE PROPOSED CONCEPT

Name of the concept. Sponsorship

What is your concept? Win the sponsor benefits by inviting a person(s) to the platform. The aim is to attract new users by using the snowball effect and professional or student networks. This sponsorship system helps guide newcomers so that they do not feel lost when they arrive on the site.

Illustration:



How does your value proposal meet customer needs? (1) Faster integration to the Makake* community for sponsorees. (2) Incentive for project companies to delegate R & D. For example, a company sponsors a supplier to facilitate part of the design of a new product.

What purpose will it serve? What customer problems are you solving? (1) Increasing motivation to join the platform. (2) Not going on the platform by oneself (3) Quickly understanding how the platform works. (4) Training and free information for Makake. (5) Financial benefits for the sponsor. (6) Creating a community of makers.

What is the best solution? This is a proven method for other platforms, for example, online banking.

[a]Before being called Kicklox, the company's name was Makake (http://www.mtom-mag.com/article4224.html).

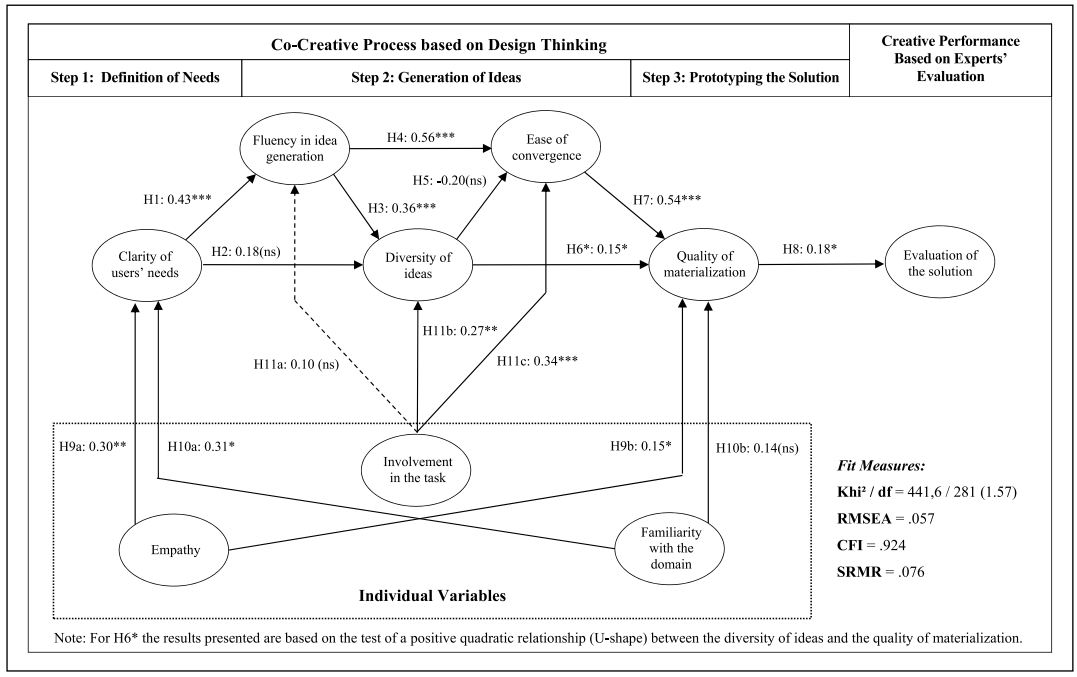
Appendix 3. Means, standard errors, and correlation matrix.

Variables	M	σ	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1. CLAR1	4.57	1.30	1																								
2. CLAR2	4.76	1.20	0.613	1																							
3. FLU1	4.53	1.14	0.351	0.349	1																						
4. FLU2	4.56	1.22	0.275	0.307	0.649	1																					
5. FLU3	4.90	1.18	0.095	0.097	0.555	0.624	1																				
6. DIV1	5.03	1.16	0.308	0.215	0.372	0.286	0.316	1																			
7. DIV2	4.99	1.23	0.334	0.254	0.399	0.286	0.281	0.717	1																		
8. DIV3	4.73	1.34	0.240	0.231	0.310	0.191	0.169	0.464	0.460	1																	
9. CONV1	5.03	1.34	0.240	0.214	0.184	0.035	0.072	0.338	0.280	0.427	1																
10. CONV2	5.40	1.18	0.232	0.238	0.154	0.056	0.132	0.308	0.292	0.329	0.660	1															
11. CONV3	5.35	1.29	0.339	0.281	0.233	0.173	0.189	0.447	0.370	0.347	0.595	0.722	1														
12. MAT1	5.18	1.17	0.295	0.336	0.328	0.155	0.200	0.325	0.303	0.452	0.541	0.433	0.349	1													
13. MAT2	5.68	1.08	0.205	0.274	0.284	0.157	0.124	0.305	0.243	0.396	0.456	0.351	0.307	0.640	1												
14. MAT3	5.38	1.36	0.275	0.173	0.221	0.189	0.153	0.273	0.263	0.367	0.287	0.351	0.312	0.479	0.452	1											
15. MAT4	5.02	1.35	0.226	0.254	0.221	0.202	0.118	0.251	0.241	0.278	0.380	0.350	0.340	0.596	0.407	0.437	1										
16. EVAL1	4.06	1.38	0.100	0.153	0.060	0.017	−0.055	0.123	0.006	0.021	0.184	0.065	0.102	0.137	0.074	−0.085	0.130	1									
17. EVAL2	4.31	1.44	0.108	0.158	0.094	0.017	−0.006	0.073	0.003	0.029	0.183	0.081	0.075	0.149	0.107	0.029	0.134	0.742	1								
18. EVAL3	4.25	1.44	0.121	0.182	0.095	0.030	0.038	0.138	0.049	0.078	0.194	0.119	0.118	0.132	0.098	0.004	0.103	0.671	0.879	1							
19. EMP1	4.54	1.32	0.256	0.213	0.165	0.107	0.121	0.136	0.187	−0.005	0.057	−0.027	0.102	0.104	0.016	0.051	0.147	0.225	0.207	0.252	1						
20. EMP2	4.78	1.31	0.227	0.255	0.192	0.155	0.202	0.044	0.223	0.055	0.024	−0.050	0.032	0.210	0.123	0.025	0.124	0.184	0.199	0.243	0.675	1					
21. EMP3	4.51	1.58	0.162	0.177	0.191	0.069	0.229	0.037	0.174	0.116	0.011	−0.093	−0.038	0.215	0.028	0.018	0.115	0.144	0.167	0.184	0.556	0.624	1				
22. FAM1	3.69	1.38	0.230	0.210	0.123	0.073	0.029	0.171	0.093	0.187	0.114	0.162	0.140	0.231	0.141	0.156	0.143	0.067	0.114	0.176	0.178	0.155	0.124	1			
23. FAM2	3.84	1.41	0.222	0.175	0.170	0.216	0.139	0.161	0.124	0.187	0.078	0.191	0.192	0.250	0.194	0.274	0.194	−0.001	0.024	0.039	0.146	0.110	0.064	0.606	1		
24. IMPL1	4.76	1.29	0.226	0.213	0.276	0.172	0.304	0.085	0.201	0.141	0.252	0.278	0.316	0.272	0.170	0.223	0.305	0.028	−0.027	0.069	0.312	0.157	0.138	0.260	0.207	1	
25. IMPL2	4.30	1.30	0.176	0.271	0.300	0.267	0.297	0.153	0.193	0.178	0.187	0.225	0.285	0.308	0.188	0.243	0.354	0.078	0.113	0.163	0.206	0.122	0.130	0.194	0.245	0.672	1

Appendix 4. Item descriptions and testing the measurement model.

	Partial. standardization	σ	*t* test	p value
Clarity of users' needs (CLAR)[a]				
CLAR1. Users' needs were clear for my team.	0.79			–
CLAR2. I think we have understood the needs of users.	0.77	.125	7.2	0.000
Fluency in idea generation (FLU)[a]				
FLU1. Ideas of solution came easily.	0.85			–
FLU2. Ideas of solution linked up easily.	0.83	.098	10.7	0.000
FLU3. Exchanges around the generation of ideas were fast and fluid.	0.58	.093	7.6	0.000
Diversity of ideas (DIV)[a]				
DIV1. To meet the needs of users, we produced various solution ideas.	0.81			–
DIV2. We proposed a wide variety of solution ideas.	0.81	.104	10.1	0.000
DIV3. We managed to produce ideas that are very different from each other.	0.72	.111	9.3	0.000
Ease of Convergence (CONV)[a]				
CONV1. The choice of the final concept came naturally.	0.77			–
CONV2. We easily came to agreement on the concept to adopt.	0.86	.088	11.3	0.000
CONV3. There was a high level of agreement regarding the concept to adopt.	0.82	.095	10.8	0.000
Quality of materialization of the solution (MAT)[a]				
MAT1. We managed to come up with a concrete concept to meet the needs of users.	0.87			–
MAT2. Through our concept, we managed to satisfy at least one user need.	0.71	0.077	9.8	0.000
MAT3. We have proposed a concept that the company can very easily implement.	0.59	0.099	7.9	0.000
MAT4. We managed to come up with a very concrete version of our concept.	0.67	0.097	9.2	0.000
Evaluation of the solution (EVAL)[b]				
EVAL1. Ordinary/unique	0.76			–
EVAL2. Not attractive/attractive	0.90	0.095	13.1	0.000
EVAL3. Without value/with value	0.98	0.101	13.5	0.000
Empathy (EMP)[a]				
EMP1. I am often told that I can understand how people feel and think.	0.79			–
EMP2. I can intuitively and quickly put myself in other people's shoes.	0.86	0.105	10.2	0.000
EMP3. I can tell if someone is hiding their real emotions.	0.72	0.118	9.3	0.000
Familiarity with the domain (FAM)[b]				
FAM1. Not at all familiar/very familiar	0.79			–
FAM2. Not at all knowledgeable/very knowledgeable	0.77	0.198	5.0	0.000
Involvement in the task (IMPL)[b]				
IMPL1. Not at all involved/very involved	0.86			–
IMPL2. Not at all focused/highly focused	0.78	0.123	7.5	0.000
Goodness-of-fit measures: χ^2/df = 366.8/239 (1.54) RMSEA = 0.055 CFI = 0.938 SRMR = 0.054				

RMSEA: root mean square error approximation; CFI: comparative fit index; SRMR: standardized root mean square residual.
[a]Seven-point scale going from *strongly disagree* to *strongly agree*.
[b]Seven-point semantic differentiator.



Appendix 5. Results of the proposed model.

For H6*, the results presented are based on the test of a positive quadratic relationship (U-shape) between the diversity of ideas and the quality of materialization.

→Statistically significant effects: * for $p<.05$; ** for $p<.001$, and *** for $p<.001$.

⇢Non-statistically significant effects: (ns) for $p>.05$.