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Gamified Software to Support the Design of Business Innovation

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Abstract: Business innovation is a process that requires creativity, and benefits from extensive collaboration. Currently, computational support in creativity processes is low, but modern techniques would allow these processes to be sped up. In this context, we provide such a computational support with software for business innovation design that uses computational creativity techniques. Furthermore, the software enables a gamified process to increase user engagement and collaboration, which mimics evolutionary methods, relying on a voting mechanism. The software includes a business innovation ontology representing the domain knowledge that is used to generate and select a set of diverse preliminary representations of business ideas. Indeed, the most promising for novelty and potential impact are identified to ignite a business innovation game where team members collaborate to elaborate new innovation ideas based on those inputs until convergence to a shortlist of business model proposals. The main features of the approach are illustrated by means of a running example concerning innovative services for smart cities.

Keywords: computational creativity; ontology; collaboration; gamification; business innovation

1. Introduction

Several scientists and analysts agree that artificial intelligence (AI) will play a major role in the future, and that intelligent machines could increasingly replace humans on the job market [1]. However some professions seem to be less threatened, as they concern mental processes that machines are not completely able to reproduce. One of these mental processes involves *creativity*, which is *"the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints)"* [2]. Innovation is the complex process of introducing novel ideas into use [3]. Hence, business innovation is an example of an activity where creativity is required as entrepreneurs continuously need new ideas. Furthermore, business models are currently the conceptual structures most used by entrepreuners to develop and specify their business ideas, which is a fundamental step of the business innovation process. According to Osterwalder and Pigneur [4,5], a business model describes the rationale of how an organization creates, delivers, and captures value. In particular, these models concern the identification of elements such as value proposition, customer segments, and key partners. From an analysis of the business innovation domain, we identified the following two key observations as the ground of our research: (a) To the best of our knowledge, there are currently no computational tools designed specifically for automatic creativity stimulation when conceiving new business ideas; (b) Business innovation is usually restricted to a few people involved in self-referential and endless brainstorming sessions and workshops [6]. In this context, our research questions are the following. RQ1: How can a machine support the creative process? As gamification is widely

considered as a promising approach to increase human engagement [7], RQ2: How can gamification be combined with such machine-supported processes to strengthen participation and collaboration?

We tackle these questions from both methodological and engineering perspectives. In particular, we present a novel framework for the participatory design of new business ideas to show that approaches based on creativity support tools [8] are viable. Participatory design is here intended as an open collaboration approach where stakeholders at any level (e.g., internal or external to the organization) are involved in the design process [9,10]. In this respect, we use gamification to enhance effective participation. According to Deterding et al. [11], gamification is the use of game design elements in non-game contexts. It aims at motivating and increasing user activity, and it is used in different contexts, such as training in enterprises. Thus, the proposed framework includes a software application based on semantic technologies to suggest preliminary business ideas and a collaborative gamified process to support their evolution. As this framework is multi-disciplinary, for the convenience of the reader, we report a glossary of the main terms at the end of the paper.

The first challenge in developing the framework was to simulate human-based reshuffling of business concepts aimed at proposing creative insights (i.e., creative sparks) that could be used as the input of a collaboration process among smart and open-minded people interested in disruptive innovation. Toward this purpose, we faced two problems. First, there is the need to determine how much an artificially generated creative spark is reasonable and/or likely. For this reason, full automation of this approach requires the availability of a formal specification of common-sense knowledge [12]. Then, the creative spark should be novel and relevant. The evaluation of creative ideas and automatic approaches to generate them are currently an open issue in the artificial intelligence (AI) research field as discussed by Forde and Fox [13] and Lamb et al. [8]. One of these approaches is computational creativity that is a subfield of AI research aimed at building and working with computational systems that create artefacts and ideas [14].

The second challenge is related to knowledge management, as innovation often requires multidisciplinary competences that are not easy to acquire. For this reason, we adopted a two-fold approach. First we use formal explicit knowledge gathered in an ontology (i.e., a formal, explicit specification of a shared conceptualization as per Gruber [15] and Borst [16]). Then, in our framework, we exploit the contribution of a group of persons in order to also use tacit knowledge. Although the framework is general from a technical perspective and can also be applied to other types of information/knowledge-gathering contexts, here we show its usage in the definition of business models for new smart city services. Toward this aim, we developed a business innovation ontology for the smart city.

The framework considers the design of business innovation as a three-phase process. The first phase involves an innovation team composed of stakeholders, domain experts, and knowledge engineers, and begins with a set of activities aimed at collecting different types of knowledge to be gathered in an ontology. Then, one or more design patterns are defined to represent idea models for creative sparks. The second phase concerns a gamified collaboration process we defined following the divergent–convergent thinking structure for creativity. The process is performed by the innovation team, who starts by selecting a set of diverse creative sparks for business modes. Then, supported by our tools in subsequent refinements of the models, and following the game rules that we defined, the team uses those models to finalize a shortlist of innovative ideas to be tested in the third phase performed in the real-world context. In this proposal, gamification enhances computational creativity methods in both the collaboration aspect of the creative process and the value of the outcomes. Indeed, gamification addresses participation and activity level, which has impacts on the number of generated business ideas. Additionally, gamification allows acceleration of the value improvement process of the proposals being made. This is achieved by a voting mechanism, as this value reflects, for example, on points assignment.

Here we focus on the first two phases of our business innovation design process. We already presented a preliminary version of our work [17], with a case study on business intelligence. Here we present an extension of the framework with a gamified collaboration process supported by a tool that guides users in the evolution from an automatically generated creativity spark to an innovative idea.

We present the architecture for the participatory design of business innovation that consists of the CREAM (CREAtivity Machine) software leveraging computational creativity and semantics-based techniques, as well as a collaboration tool, the ICE4B (Innovation through Collaborative Environment for Business) mobile app, which enables a well-defined gamified creative process and operates on some guidelines. We addressed RQ1 and RQ2 described earlier by providing CREAM and ICE4B.

The rest of the paper is organized as follows. Section 2 presents related work concerning participatory innovation processes, gamification, and information and communications technologies (ICT) systems used to support them. Section 3 presents the knowledge-based methodology to support it. Section 4 describes the software architecture for the participatory design of business innovation, including a domain ontology, the computational creativity tool, and a description of the gamified collaboration process. Section 5 illustrates the running example concerning business innovation for smart cities. Finally, Section 6 presents conclusions.

2. Related Work

Innovation is a relevant topic in the business community that is striving to define new paradigms to better understand it and facilitate innovation processes. An example is the open innovation paradigm defined by Chesbrough [18], which is based on the idea that *"new valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well"*. This paper deals with the innovation process. One of the seminal works concerning this research topic is TRIZ (the Russian acronym for theory for inventive problem solving) [19]. This book faces the problem of "inventing methods of inventing" and defines some rules for brainstorming concerning how to build the "idea-generating team", the time limit for expressing ideas, the behavior to be held by participants (e.g., no criticism is allowed), and which ideas should be considered (e.g., also the frivolous ones). Another theoretical method is lateral thinking [20]—a method to solve problems with creativity based on not-obvious reasoning. According to De Bono [20], the vertical thinking approach tries to find the best solution to a problem, whereas lateral thinking generates as many alternative solutions as possible. With respect to these, we propose to use artificial intelligence techniques (i.e., based on an ontology) to support the innovation process.

The European Project BIVEE (Business Innovation for Virtual Enterprise Ecosystems) [21] proposed the support of innovation processes that leverage ontologies. Other existing works based on ontologies were presented by Yan et al. [22] and by Zanni-Merk et al. [23]. With respect to these, our solution is more flexible, as it is not tied to a specific ontology or upper model.

On the other hand, we share the computational creativity approach with Apostolou [24] and Zachos [25]. This consists of using technologies to assist humans in thinking novel, disruptive, and unlikely ideas. However, with respect to them, we propose to use artificial intelligence techniques based on an ontology.

Existing collaboration systems such as BSCW, Slack, and Trello are general-purpose and were not explicitly conceived to support new ideas and innovations. Innocentive [26] is a platform that aims at stimulating new solutions and ideas leveraging crowdsourcing technologies and a rewarding system. As with Innocentive, IdeaScale is an innovation management platform based on crowdsourcing technologies. With these works we share the goal of involving a group of people in brainstorming activities, but our work is complementary as we propose to automate the preliminary activities of idea generation and, hence, to stimulate the collaboration process with preliminary models of ideas generated by a software system.

Gamification is an effective means to increase the motivation of users (e.g., employees) [27]. A literature review of empirical studies on gamification according to a framework examining its effects based on motivational affordances, psychological outcomes, and behavioral outcomes is presented by Hamari et al. [7]. A method to design gamification and developing gamified software is presented by Morschheuser [28]. Gamification is currently used in the business context, and there are several existing software platforms, such as CallidusCloud (CallidusCloud url: https://www.calliduscloud.com/salesmotivate), Bunchball (Bunchball url: https://www.bunchball.com), and Mambo.io (Mambo.io url: https://mambo.io). With respect to existing gamification solutions, our proposal is integrated with a computational creativity system based on semantic techniques.

3. Knowledge-Based Methodology to Foster Innovation

We follow the perspective of the collective intelligence of ideas. Collective intelligence is defined by analogy with individual intelligence, as the general ability of the group to perform a wide variety of tasks [29]. In particular, we use the view showing that collective intelligence originates from data/information/knowledge, hardware/software, and groups of experts. We specialized this view as in Figure 1 to represent that, in our proposal, business innovation ideas require business knowledge, computational creativity, and gamified collaboration. These are the main ingredients to foster business innovation.

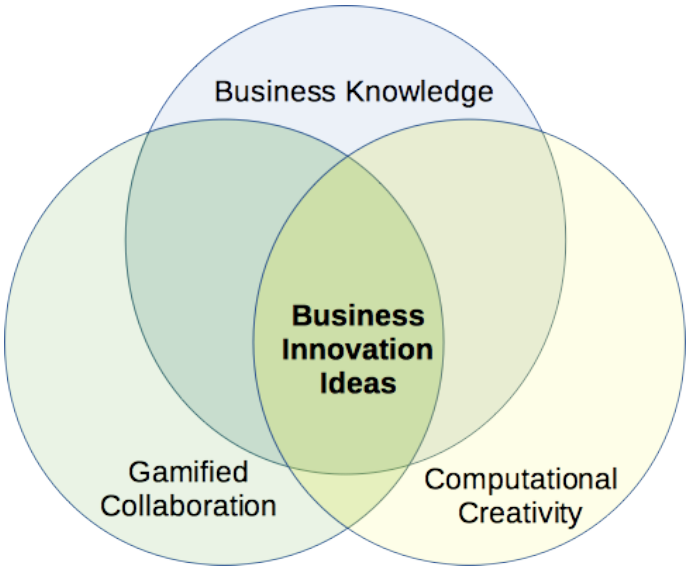

Figure 1. Our approach to business innovation ideas, which requires computational creativity, gamified collaboration, and business knowledge.

The proposed methodology is supported by software tools, used to enhance both human participation in a business innovation session and the creative activity itself. Indeed, the aim of the methodology is to design novel business ideas for innovation in the form of business model instances. This is accomplished by leveraging business knowledge available both as explicit knowledge, formalized through an ontology, and as implicit and tacit knowledge from humans taking part in innovation teams. An innovation team includes stakeholders and domain experts to provide business knowledge concerning the specific application, as well as knowledge engineers to support the elicitation, collection, and formalization of that knowledge. Thus, formal explicit knowledge is the grounding upon which intelligent tools facilitate the design of new promising business ideas, by automatically supplying conceptual models for such ideas, which we named "creative sparks". In turn, based on creative sparks, the innovation team's experience and creativity may contribute to further enrichment of the business knowledge. The collaborative work required by the innovation team about reasoning on creative sparks is enhanced through gamification of the creative process.

Game elements such as rewards based on contributions allow the expansion of peoples' engagement. Game mechanics settings such as *play roles* (e.g., facilitator, actor to provide different views), and idea structure based on patterns and rules allow the creative process to be conducted towards successful ideas for innovation.

Figure 2 shows our methodology as a macro-process. According to Alex Pentland [30], creative people have new ideas by means of an exploration process. They make conceptual connections stimulated by meeting new people and knowing different opinions. Once they have a new intuition, they refine it with their network of contacts. Accordingly, we distinguish two temporal phases, comprising activities from the supply of the creative spark(s) to the final definition of a successful idea that will be implemented. These phases involve ICT tools supporting the human work as well as real-world experimentation. The first phase refers to creative spark(s) selection, among those automatically generated by the CREAM tool, and their analysis by the innovation team based on the explicit business knowledge. Supplied creative sparks are indeed evaluated by the participants of the team, who may decide to elaborate one or more of them by describing them as business stories. The overall team activity is coordinated by a gamified and creative collaboration process supported by a tool that iterates until convergence on promising business ideas. Hence, the business ideas that are not considered as promising are discarded and named "bad ideas". Please note that since the evaluation process is subjective, those ideas can also be considered as missed opportunities. Furthermore, a bad idea could be considered as innovative in subsequent iterations of the innovation process. Instead, in case the innovation team deems that a business idea is promising, it will focus on it and possibly elaborate some variations, eventually using the available computational creativity functions described in Section 4.2 to finally produce an innovative idea. The third phase deals with the effective elaboration of the innovative idea in the real world, to end up either with a successful idea (if the innovative idea is actually used), or with a failure and, possibly, a lesson learnt. Failures and lessons learnt can be used to refine the knowledge base but also to improve the definition of innovative ideas in subsequent iterations of the innovation process.

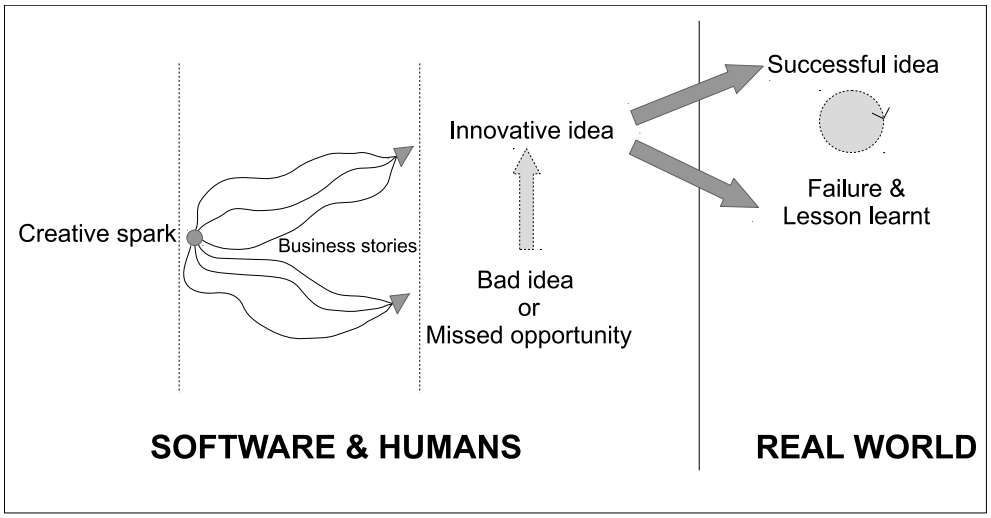

Figure 2. Lifecycle of an idea: from the creative spark(s) to a successful idea for innovation.

4. Architecture for the Participatory Design of Business Innovation

In this section we present in detail the main components of the software architecture (Figure 3) for the participatory design of business innovation. Namely, it consists of: the ontology formalizing business knowledge, which is the conceptual basis of the business innovation modeling activity; CREAM, implementing computational creativity techniques as means to the automatic generation and exploration of creative sparks for innovation; and ICE4B, the gamified collaboration tool, implementing

the process of the innovation team. This software supports the idea lifecycle illustrated in Figure 2, from the creative spark(s) to a successful idea for innovation.

4.1. Business Innovation Knowledge for Smart Cities

The proposed framework requires two types of business innovation knowledge. The former is formal and explicit, which is available in a business domain ontology for innovation. The latter is the implicit and tacit knowledge, for instance, owned by employees of an enterprise.

A widely accepted tool to design a business model is the "business model canvas", which resembles a painter's canvas and allows the depiction of business models. It consists of nine essential building blocks working supportively together. For the sake of simplicity, here we consider an idea pattern consisting of only five building blocks. The *customer segment* building block defines the different groups of people or organizations that an enterprise aims to reach and serve. The *value proposition* building block describes the bundle of products and services that create value for a specific customer segment. The *channel* building block describes how a company communicates with and reaches its customer segments to deliver a value proposition. The *key activity* building block describes the most important things a company must do to make its business model work. The *key partnership* building block describes the network of suppliers and partners that make the business model work. The other building blocks not considered in this example are customer *relationship*, *revenue stream*, *key resource*, and *cost structure*.

We formalized a business innovation ontology for smart cities (business innovation ontology for smart cities url: https://tinyurl.com/BIOforSmartCities) by specializing the concepts corresponding to the above-mentioned building blocks. The ontology currently concerns four domains, which include energy, living, public and private transportation, and telecommunications, considered mainly from a business perspective. The ontology was built by using Protégé (Protégé url: https://protege.stanford.edu), an ontology management system developed by Stanford University. It includes 264 classes and 362 SubClassOf relationships. Figure 4 shows an excerpt from the ontology representing the sub-hierarchy of the concept "Living value proposition". This is depicted as a graph by using GEPHI (GEPHI url: The Open Graph Viz Platform (https://gephi.org)). The red node represents the concept "Living value proposition". Brown nodes represent the concepts at the first level of specialization, and green nodes represent the concepts at the other levels of specialization.

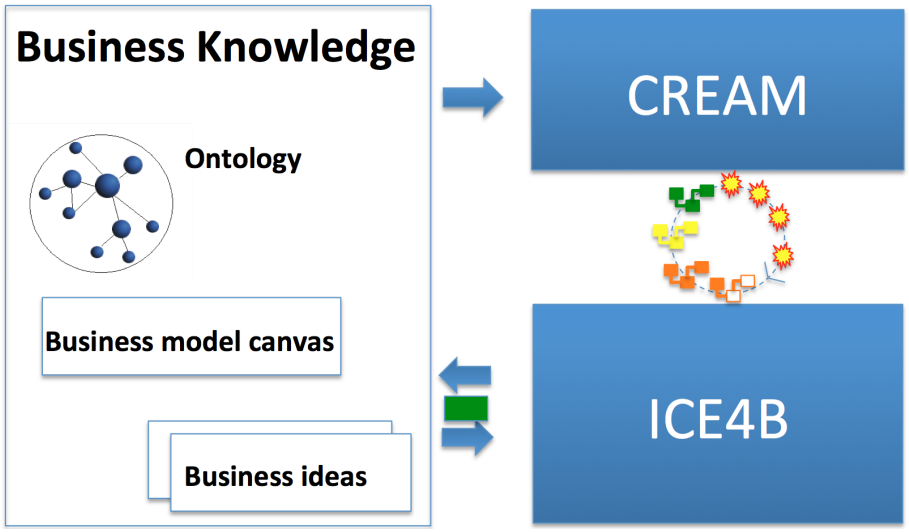

Figure 3. Architecture of the gamified software including CREAM (CREAtivity Machine), ICE4B (Innovation through Collaborative Environment for Business), and a business knowledge repository.

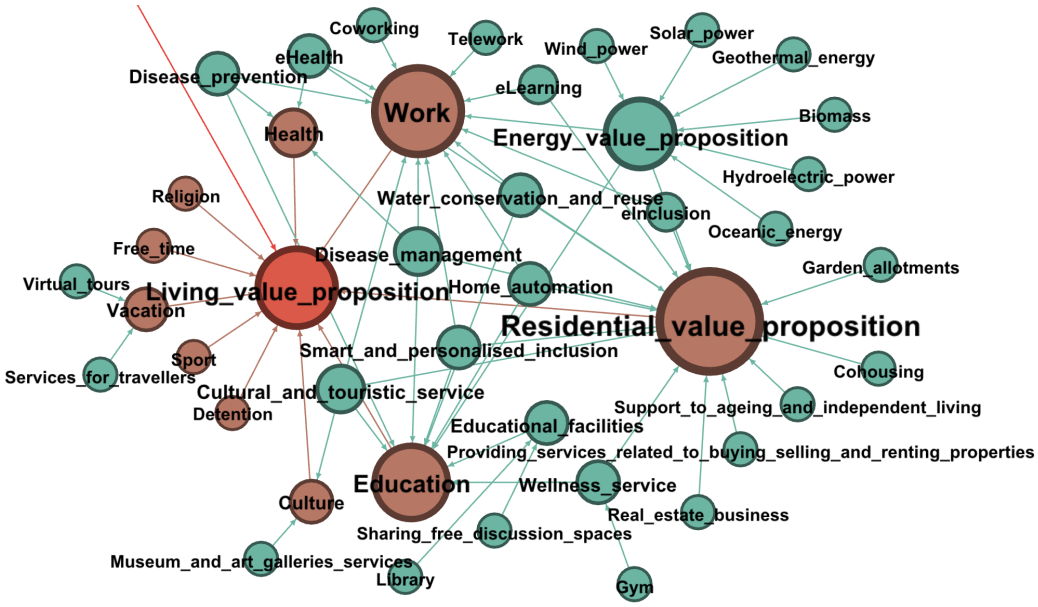

Figure 4. An excerpt from the business model ontology for smart cities representing the sub-hierarchy of the concept "Living value proposition". This is depicted as a graph by using GEPHI. The red node represents the concept "Living value proposition". Brown nodes represent the concepts at the first level of specialization, and green nodes represent the concepts at the other levels of specialization.

4.2. Computational Creativity Tool

As already mentioned, the tool to generate and explore the creative sparks for business innovation is named CREAM [31], and was developed more generally to support creative thinking in any domain where knowledge is formalized in a taxonomy-based ontology and in logical rules, and the ideas are structured by means of ontology design patterns [32]. The domains we have analyzed so far include emergency management [33], risk and safety assessment [34], and business innovation [17]. This section actually extends the last work, which was applied to the business intelligence case study after a deeper analysis of the requirements for the CREAM application in this domain. This analysis has led us to a major improvement of the software to support the innovation process based on CREAM and enhanced by gamification that is described in the next section. Here we present an extensive revision of the CREAM-based collaborative definition of innovative ideas presented by De Nicola and Villani [17], by describing the functions of the tool in more detail and how they can be used more effectively in a creative process.

Especially for the field of business innovation, creativity support is useful at all levels: *individual*, to investigate new entrepreneurial opportunities; *collective*, to enable the involvement of a larger number of employees/workers of an organization in the elicitation of new business ideas; and *organization*, to ease the step of the business innovation strategy to decision making. These needs reflect the following main technical requirements for CREAM usability in this domain: *simplicity* of the model structure of the creative sparks; *richness* and *variety* of the generated instances; and *effectiveness* in their representation of business ideas. In the following, we discuss how these requirements were addressed by our CREAM-based system.

According to the definitions about creativity theory reported by Lamb et al. [8], CREAM can be considered as a computational system supporting creative processes by persons towards the design of products that are novel and valuable, according to the press (i.e., the environment).

Specifically, in this application, the creativity skill required of a person participating in a innovation team is encouraged by means of a CREAM function devoted to the automatic definition of creative sparks as instances of the chosen business model structure represented by a design pattern. This function is implemented as a selection in the concept space of the domain ontology, given a goal

description such as the area of interest of the business and context information such as location, temporal period, and market analysis results. As described in detail by De Nicola and Villani [17], the result of this function is a set of business models automatically filled with specific concepts of the ontology by means of SPARQL [12] queries. Technically, creative sparks for a given design pattern are conceived as semantic bindings between abstract entities of that structure and domain-specific entities of the ontology, in order to represent possible concrete innovative ideas for the business. This selection is performed by accounting for the upper-level concepts and relationships that are used in the given design pattern, in order to retrieve all of their specializations from the domain ontology. The resulting business models are potential creative products to be analyzed and elaborated by persons. To improve precision on novelty, this function also accounts for the set of known business models previously stored in the system (this is referred to as exploratory creativity in the literature [8]). Additionally, a finer search on value is performed by means of specific relevance metrics, based on known successful business models, and associated with individual or group of concepts of the ontology.

Other functions provided by CREAM are devoted to heuristics-based generation of the creative sparks and to support their evolution towards a collaborative human definition of innovative ideas. Generally, heuristics are shortcuts that can allow people to solve problems more quickly and efficiently. In our work, we propose some heuristics based on computational creativity theory [35], as described below. This process relies on the collaborative work of various persons involved in the innovation management process, leveraging their experience and different expertise, creativity, and problem-solving capabilities, based on organization knowledge and supported by the CREAM-based application. In particular, our implementation of computational creativity combines: the automatic generative method [8] described above through semantic reasoning techniques, and a search-based approach using metrics based on concepts similarity and relevance, with a cognitive perspective by enabling the innovation team actions in the idea life cycle from the creative spark to a "fully-fledged" innovative idea.

Indeed, according to the process view of computational creativity [35], creative design can be achieved by iteratively applying some heuristics-based actions mimicking the operations of evolutionary algorithms. An application-specific interpretation of these actions and how they are supported by CREAM, which extends the discussion in De Nicola and Villani [17], is a relevant step to describe the gamified innovation process of the next section.

- *Business model combination*: taking concepts from two or more existing business models, or creative sparks already visited, to generate a new creative spark. An example is to combine parts of business models that refer to different areas. This operation is performed by the persons, whereas CREAM currently supports them through query and search functions of the source business models/creative sparks. Indeed, the semantic similarity metrics can be used to select a group of *different* business models/creative sparks, and the relevance metrics to prioritize them.
- *Business model transformation*: modifying one or more features of an existing business model, or creative spark, to generate a new one. This operation can either be attempted directly by CREAM through automatic replacement of one concept of the model with another one chosen at random, or performed manually by a person.
- *Analogy-based search of a business model*: a successful business model of some area is used as reference to generate a new creative spark for another area. For this operation, which again is carried out by the persons, CREAM provides search functions based on semantic similarity to query successful business models with similar business objectives, or, conversely, given such a case, to generate a new creative spark similar to it.

Our proposal consists of leveraging the effectiveness of these types of operations, well-known in computational creativity works, and the dynamics of evolutionary methods to provide the game mechanics of a gamified creative process based on collaboration, which is the novelty of this work. Compared to some other application domains we have explored to-date, such as the design of emergency

scenarios [31], the size of the concept space is smaller as the application is more focused. Hence, the selectivity of the tool is more effective. With respect to safety/risks elicitation for critical infrastructures [34], here divergent/convergent thinking within a collaborative process is directly addressed by the tool.

4.3. Gamified Collaboration Process

In our proposal, a gamified collaboration process enhances the computational creativity approach with the final aim of driving the participatory design of business innovation. However, before the gamified process starts, the innovation team has to fulfill some preliminary activities. First it has to define the scope of the business model by focusing on a sub-sector of the smart city domain (e.g., energy, living, transportation). Then, the team identifies the coordinator, who is in charge of proposing a preliminary subset of creative sparks generated by CREAM to the rest of the team, finalizing the business model collection process, and accepting and/or rejecting business model proposals.

The gamified collaboration process is depicted schematically in Figure 5. This represents the main steps of the process. First, some creative sparks are generated by CREAM and selected by the coordinator as a basis for business models to be considered by the other participants. At this point, each participant can select a creative spark and build a business model upon it, by providing an interpretation of the conceptual model and a textual description. Of course, a participant can create more than one business model. Authors of business models take the role of proposer. A milestone is defined by the coordinator for collecting the first set of business model proposals. Then, all of these proposals are made public and voted by all the participants of the game. At the second milestone, the ranking of the proposals is revealed. At this point, the participants are invited to try to improve the proposed business models. They may do this by exploiting the CREAM heuristics-based functions described in Section 4.2, such as combination, transformation, and analogy-based search functions. Any participant who elaborates upon a business model proposal either individually or collaboratively will take the role of contributor. Of course, low-scored business model proposals are less likely to be selected for improvement, but it may still be possible for other participants, or the proposer herself, to re-think those ideas and to transform them in successful business models. All the updated business model proposals are then voted on again. Those with low score that have not been improved will be discarded in the subsequent iterations of the last two phases. The game will end either when a small number of business process models (e.g., three) have been recognized as the best (i.e., by convergence); when a previously decided time end is reached; or if the coordinator decides to stop it.

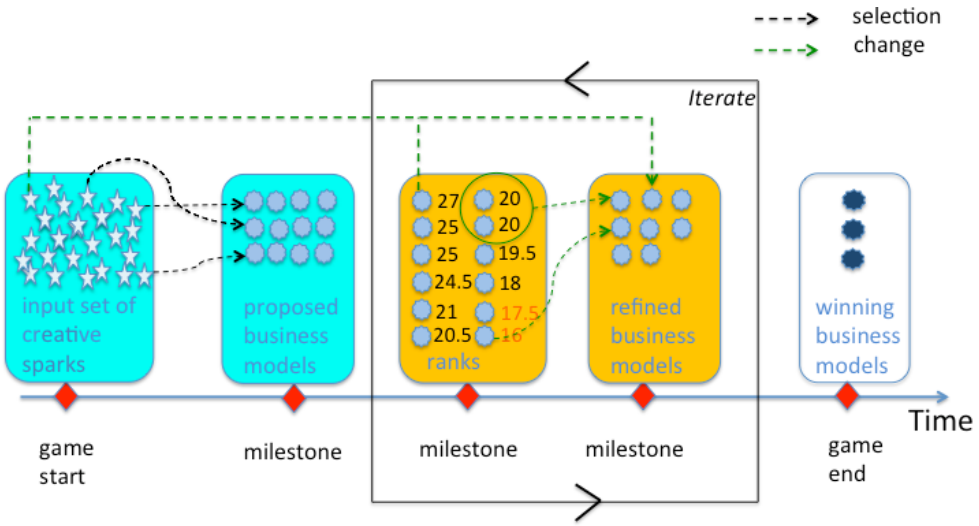

Figure 5. Gamified collaboration process. Activities performed at the individual level are in the blue boxes, whereas the iterated activities of evaluation and refinement of business models, performed collaboratively, are in the orange boxes.

Figure 6 depicts the same gamified process as a Unified Modeling Language (UML) activity diagram to present the detailed activities of the participants working on a single business model proposal. As in the previous figure, the blue part concerns activities performed individually, whereas the orange part those performed collaboratively. Participants performing most of these activities win points. Indeed, the objective is to increase their engagement and participation. An example of how points can be assigned is presented in Table 1. The higher the degree of participation, higher the amount of points won.

According to the process depicted in Figure 6, the coordinator selects some creative sparks (Select creative sparks) and proposes them (Propose creative sparks) to the other members of the innovation team. Then, business model proposers read the above-mentioned proposals (Read creative spark) and either reject them (Reject creative spark) or accept them (Propose business model). It should be noted that in the last case the creative spark is promoted to the status of a business model. At this stage, business model contributors can collaborate in better defining the proposed business models. They read those already proposed (Read business model) and can decide (Decide for approval) to either modify (Modify business model) or accept (Accept business model) them. Then, business model proposers assess—if any—the requested changes (Assess modification) and decide either to accept (Accept modification) or reject (Reject modification) them. Then, if the coordinator has finalized the business model collection phase (Finalize business model), proposers can submit business models to her (Submit business model to coordinator) and contributors can decide (Decide for endorsement) to endorse them (Endorse final business model). Finally, the coordinator receives voted business models (Receive business model) and can decide to accept (Accept business model) or reject them (Reject business model proposals) according to their scores.

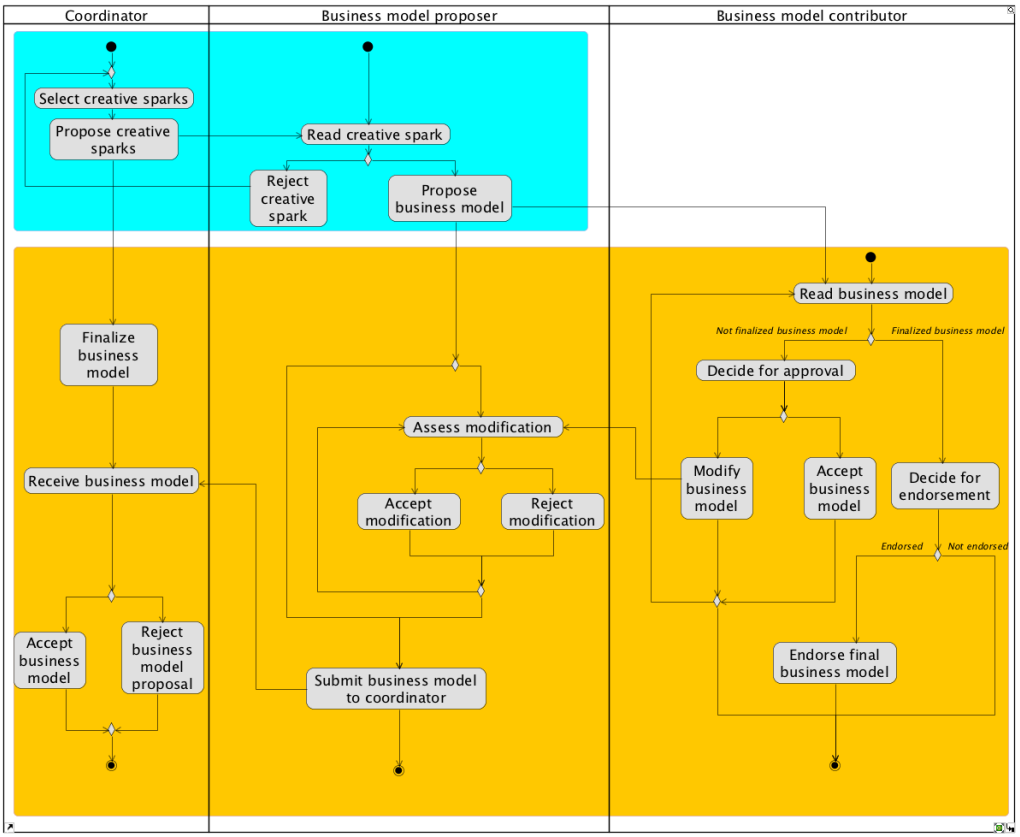

Figure 6. Gamified collaboration for definition of a business model. Activities performed at the individual level are in the blue boxes, whereas the iterated activities of evaluation and refinement of business models, performed collaboratively, are in the orange boxes.

Table 1. Points won by the coordinator, proposers, and contributors for the performed activities aimed at business model definition. Harvey balls indicate the amount of points: ○ indicates no points and ● indicates four points.

Player Activity	Points	Points Recipient
Coordinator proposes creative sparks	◑	Coordinator
Business model proposer proposes business model	◕	Proposer
Business model proposer rejects creative spark	◔	Proposer
Business model contributor modifies business model	◑	Contributor
Business model contributor accepts business model	◑	Contributor
Business model contributor endorses final business model	◔	Contributor
Business model proposer accepts modification	◔	Proposer
Business model proposer rejects modification	◔	Proposer
Business model proposer submits business model to coordinator	◔	Proposer
Coordinator accepts business model	●	Coordinator
Coordinator rejects business model proposal	◑	Coordinator
Coordinator assigns extra points based on participation in risk mini-model definition (number of preliminary acceptances and final endorsements of risk mini-model)	from ◔ to ●	Team

The existing literature on gamification agrees that these game elements (i.e., voting and winning points) increase peoples' engagement [7], and therefore we use them. Furthermore, as Chesbrough states in his successful book on open innovation, participation is a fundamental driver for business innovation [18]. Hence, we deem that voting and winning points are factors that drive business'innovation.

The gamified collaboration process can be implemented by both a web application and a mobile app. Here we briefly present ICE4B, the mobile app we developed for this purpose. ICE4B allows the innovation team to interact with proposed creative sparks and business models. They can propose, approve, reject, and describe them as narratives. Furthermore, they can propose changes to creative sparks and business models by leveraging CREAM functionalities presented in Section 4.2. Finally, ICE4B allows users to manage participants and visualize the leaderboard. Two screenshots of ICE4B are depicted in Figure 7. The left part of the figure shows the simplified structure of the business model presented in this paper, whereas the right part shows an example of an actual business model where home automation is the value proposition, retailer is the channel, elderly people is the customer segment, an internet provider is the key partner, and remote control telemedicine is the key activity. This business model is further elaborated in the next section (see *Business model 2* in Section 5).

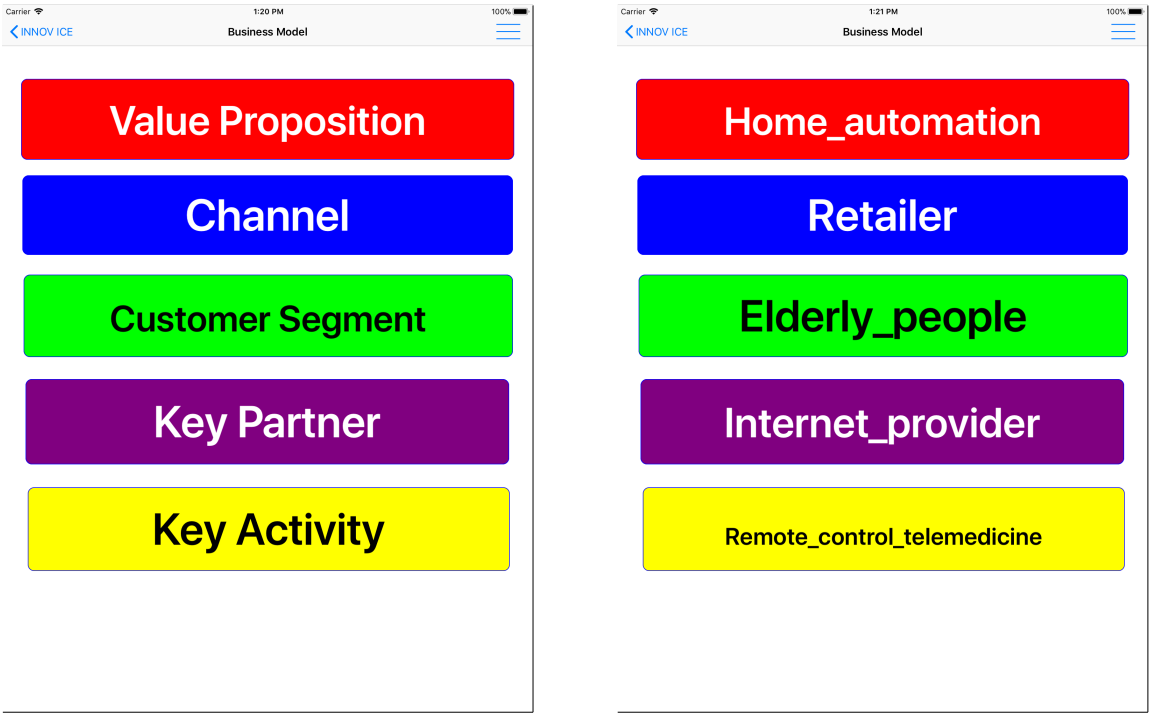

Figure 7. Screenshots of ICE4B. The left part of the figure shows the simplified structure of the business model presented in this paper, whereas the right part shows an example of an actual business model where home automation is the the value proposition, retailer is the channel, elderly people is the customer segment, an internet provider is the key partner, and remote control telemedicine is the key activity (see *Business model 2* in Section 5).

5. Business Innovation for Smart Cities

To the sake of clarity, here we present a walkthrough example where we describe the activities of an innovation team devoted to building a business model for smart cities. As mentioned, before the gamified process starts, the innovation team has to fulfill some preliminary activities, such as defining the scope of the business model and identifying the coordinator. In our example, the innovation team decides to focus on the energy business domain.

The coordinator proposes some creative sparks to the rest of the innovation team and, hence, wins two points. Then, a business model proposer selects one of them, proposes the following business model (*Business model 1*), and wins three points.

Business model 1

`Value_Proposition` : `Solar_power`
`Channel` : `Internet`
`Customer_Segment` : `Foreign_Enterprise`
`Key_Partner` : `Energy_Provider`
`Key_Activity` : `Comparative_Advertising`

Furthermore, to further clarify his idea, he describes the business model as follows.

Description of *Business model 1*. An Italian company offers a service aimed at installing photovoltaic panels for solar power production as a value proposition to foreign enterprises that want to invest in Italy. The channel to sell this service is the Internet. The key activity of the business consists of providing comparative advertising to show the advantages of the business. The Italian company will also manage all the relationships with the energy distribution network operator.

Three contributors endorse *Business model 1*. Each of them wins one point. Then, the proposer submits the business model to the coordinator and wins one further point. Finally, the coordinator accepts it and wins four points. Table 2 shows the leaderboard at the end of the session.

Table 2. Example of leaderboard after the first innovation session.

Player ID	Points	Role in Session I
Player_01	7	Coordinator
Player_02	4	Proposer
Player_03	1	Contributor
Player_04	1	Contributor
Player_05	1	Contributor

In the second session, Player_05 takes the role of coordinator and proposes a new set of creative sparks: some of them concerning the residential sector and some the health sector. As seen in session 1, the coordinator wins two points. Player_03 selects a creative spark concerning the residential sector and proposes it to the rest of the innovation team. Hence, he takes the role of proposer in this session and wins three points. Player_01 decides to modify the business model. She uses the business model combination functionality of CREAM to merge the business model proposal of Player_03 with a new one concerning the health sector. This hybrid business model (*Business model 2*) is presented and described in the following.

Business model 2

`Value_Proposition` : `Home_automation`
`Channel` : `Retailer`
`Customer_Segment` : `Elderly_people`
`Key_Partner` : `Internet_provider`
`Key_Activity` : `Remote_control_telemedicine`

Description of *Business model 2*. An ACME company offers a service aimed at home automation as a value proposition to elderly people. Retailers are the channel to sell this service. The key activity of the business consists of remote control telemedicine to monitor the health conditions of elderly people. The company will also work together with the internet provider, as the availability of the internet connection is fundamental to provide the service.

Then, the contributor submits it to the proposer and wins two points. The resulting business model is then accepted by both the proposer and the coordinator. The former wins one point and the latter four points. Finally, the coordinator decides to assign four extra points to Player_01. The leaderboard is updated as presented in Table 3.

Table 3. Example of leaderboard after the second innovation session.

Player ID	Points	Role in Session II
Player_01	13	Contributor
Player_05	7	Coordinator
Player_03	5	Proposer
Player_02	4	Contributor
Player_04	1	Contributor

6. Conclusions

This paper proposes new gamified software to foster ideas in business contexts. This is based on a business domain ontology, gathering knowledge to be used to generate creative sparks for business models and, hence, to support the work of the innovation team in discussing and producing new

ideas by means of a gamified collaborative process. Creative sparks are generated by the CREAM component of the software application.

Other than being novel from the technical perspective, we deem that such a framework would provide some important benefits to the innovation process. Firstly, it facilitates the sharing of experiences among the members of the innovation team in spite of their competences. Secondly, the machine-generated creative sparks, while driving the discussion toward added creativity and original thinking, also cut across the personality barriers and the biases that often affect focus groups' deliberative objectivity. In line with the open innovation perspective, by means of a gamified process supported by our tools, it aims at a wider participation in the idea collection phase of the innovation process.

More specifically, we addressed research question RQ1 by implementing new computational creativity methods based on semantics applied to a business innovation ontology and the business model canvas. We implemented similar methods for another application domain, and they were successfully experimented as discussed in [33]. Additionally, in this work, we proposed a collaboration process that mimics evolutionary algorithms [36], well-known in the literature, where the strength of a business idea model is evaluated through voting by the participants and may be subsequently improved by using our computational creativity methods. Research question RQ2 was addressed by taking into account the increasing interest in the use of gamification in industry as an engaging mechanism, for example, with the aim of information gathering for risk and safety assessment [37]. We proposed a game model that has to be further refined and adapted to the specific organization (e.g., how to assign points and rewards). Indeed, as discussed in [7], the design of gamification software is strongly influenced by its usage context, and follows an experience-based development process.

From a managerial perspective, our work proposes an innovative approach to supporting and engaging participants in business processes requiring creativity. This could boost the productivity of enterprises. From a theoretical perspective, we: (a) defined and implemented methods of computational creativity based on semantics; and (b) modeled the collaborative process of eliciting innovation ideas as an evolutionary process of the proposals, enhanced by gamification. Furthermore, to the best of our knowledge, applications of computational creativity in the business sector are unprecedented.

The current limitation of the proposed approach is due to the effort required to build the ontology. However, there are several endeavors devoted to automating the ontology engineering process [38], which could sensitively reduce these issues.

Finally, we presented an exemplary application related to the definition of a business model for smart cities. We chose this example since it is currently a relevant topic for society and because conceiving innovative ideas in this complex sector requires multi-disciplinary knowledge and the contributions of people with different competencies. Hence, it is a good example to show the benefits and characteristics of our approach. As future work, we will be analyzing game experiences and how ideas are implemented in the case organization.

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Glossary

Business innovation. Innovation is the complex process of introducing novel ideas into use [3]. Hence, business innovation is an example of an activity where creativity is required as entrepreneurs continuously need new ideas.

Business model. According to Osterwalder and Pigneur [4,5], a business model describes the rationale of how an organization creates, delivers, and captures value. In particular, these models concern the

identification of elements such as value proposition, customer segments, and key partners.
Business model canvas. A widely accepted tool to design a business model is the "business model canvas", which resembles a painter's canvas and allows the depiction of a business models. It consists of nine essential building blocks working supportively together [5].
Collaboration. Collaboration is a process in which entities share information, resources, and responsibilities to jointly plan, implement, and evaluate a program of activities to achieve a common goal. It can be seen as a process of shared creation. Collaboration involves the mutual engagement of participants to solve a problem together [39].
Collective intelligence. Collective intelligence is defined by analogy with individual intelligence, as the general ability of the group to perform a wide variety of tasks [29].
Computational creativity. Computational creativity is a subfield of artificial intelligence (AI) research aimed at building and working with computational systems that create artefacts and ideas [14].
Creative sparks. Creative insights that can be used as the input of a collaboration process among smart and open-minded people interested in disruptive innovation.
Gamification. According to Deterding et al. [11], gamification is the use of game design elements in non-game contexts. It aims at motivating and increasing user activity, and it is used in different contexts, such as training in enterprises.
Ontology. An ontology is a formal, explicit specification of a shared conceptualization as per Gruber [15] and Borst [16].
Participatory design. Participatory design is here intended as an open collaboration approach where stakeholders at any level (e.g., internal or external to the organization) are involved in the design process [9,10].

Abbreviations

The following abbreviations are used in this manuscript:

CREAM	CREAtivity Machine
ICE4B	Innovation through Collaborative Environment for Business
ICT	Information and Communications Technologies
Sw	Software
UML	Unified Modeling Language

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