Conceptual framework of an intelligent system to support creative workshops

Alex Gabriel, Davy Monticolo, Mauricio Camargo, Mario Bourgault

Abstract In today's highly competitive economic context, companies are forced to be innovative in order to stay on track. This mandate to innovate requires companies to set up various tools to evaluate the capacity to innovate and implement innovative dynamics. Before purporting to generate innovation, it requires having ideas. Thus, creativity is in some way the upstream component of innovation. Creativity implies the production of ideas. This production of ideas can be supported by many techniques that can be classified into two categories: systematic and structured methods (TRIZ …) or explorative approaches (brainstorming, mind mapping, personas, KJ technique…). The fact is that these creative techniques can be necessary but are not enough to produce unobvious ideas. The many factors that influence the creation of a creative dynamic lead to a complex situation which is difficult to manage optimally. From among the various ways to establish a creative dynamic in organisations, this work considers the creative workshop which is a collaborative way of solving problems by maximizing the proposition of unusual ideas. In this chapter, we will discuss the need to structure activities before, during and after the workshop itself and how a support system could allow an optimal organisation of the workshop throughout the entire creative process. The components of the Creative Support System will be described and the potential impacts on the creativity process discussed.

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1. Introduction

In today's highly competitive economic context, companies are forced to be innovative in order to stay on track. This mandate to innovate requires companies to set up various tools to evaluate the capacity to innovate and implement innovative dynamics. Creativity abilities are considered to be one of the pillars for developing the firm's innovation capacities (Boly et al., 2014) (Chiesa et al., 1996). Creative competencies allow firms to explore and develop promising fields, inspire the emergence of new concepts and designs, or propose solutions for specific unsolved problems. Consequently, enhancing these competencies has become a priority for numerous organisations. Hence the methodologies and tools for supporting creativity have gained in popularity both for industry and for academia. There are two main creative approaches that can be mentioned: the Systematic Creativity (SC) approach (Ogot and Okudan, 2007) and the Creative Problem Solving (CPS) approach (Treffinger et al., 2008) (Osborn, 1963). Systematic Creativity methodologies such as TRIZ are increasingly being applied due to its ability to take systematic advantage of the available knowledge. It conducts to intelligent idea generation in areas where other people have solved similar design problems. Despite the increasing dissemination of Systematic Creativity, Creative Problem Solving (CPS) based on techniques such as brainstorming (Osborn, 1963) is still by far the most used approach (Paulus et al., 2012). However, implementing and exploiting the results of a creative workshop are time and resource intensive activities for an organisation, requiring a huge number of people and effort. Moreover, the results can be disappointing and the workshop perceived as a waste of time if the conditions are not created correctly.

On the other hand, current developments in information and communication technologies (ICT) permitted the emergence of collaborative and cooperative information systems (Boughzala, 2007). Functionalities as instant messaging, video calls, or files sharing contributed to the increase of the virtual team collaboration by enabling communication, coordination and collective problem solving (Boughzala, 2007)(Nemiro et al., 2008). These developments can potentially help to enrich further the creative process and provide new functionalities in order to apply more systematic like approaches (Zanni-Merk et al., 2011).

Despite creativity is individual, collective and organizational (Mumford, 2012), the iterative process of a creative workshop is first considered as been collective and organizational. Indeed, at each stage of this process, different actors with dif-

ferent roles and knowledge are involved in making decisions and conducting actions that impact the subsequent stages, which could make the entire creative process highly complex. In order to represent this complexity and the flow of information involved, we argue that the multi-agent paradigm can properly represent it. The agents were originally designed to model complex systems due to their properties of autonomy, interaction between them and their environment and the search for a common and individual goal. The idea of applying the agent paradigm to creativity had already been suggested (Boden, 1994) but to the best of our knowledge, no application has been implemented in the domain of Creative Support Systems.

Thus, the main issue covered by this chapter is on improving the organisation and the implementation of a creative workshop and exploiting its results through a Creative Support System (CSS) based on the agent paradigm. The systematic perspective of TRIZ somehow inspires this. However, the challenge is to retain the creative character despite the systematic use of information system and digital devices. Consequently, this chapter is organized as follows: the next section aims to give a better understanding of the evolution of innovation and creativity practices. Then section 3 positions the current systems and tools used to support the creativity process in the creative process and the used technologies. Subsequently, opportunities to improve the software currently available for assisting creativity will be addressed. Finally, in section 4 some specifications for designing a Creative Support System will be discussed before concluding on the perspective of a CSS based on a Multi-Agent System.

2. Evolution of innovation and creative practices

Innovation and design can be considered as problem solving situations which require creative and flexible though. Flexible though, which can be considered as a characteristic of creativity, means the change of mental process and representation of a situation. Whatever problem solving, design, or innovation, it is a cognitive phenomenon that can be described as a personal and goal-oriented process (Mayer, 1999). Problem solving occurs when a person has a goal but does not know how to achieve it (Ward, 2012). A solver “engages in some sort of mental computation such as applying a set of operations to knowledge in the cognitive system” (Mayer, 1999) in order to find a solution to a problem (reach the goal state). The solving strategy depends on the formalization of the problem (ill-defined/well-defined) but also which knowledge he uses. If the solver bases his resolution on similar previous problems, the problem can be considered as routine; whereas it is

consider as a creative problem, if it requires creation of new method (Ward, 2012). Based on these categories, design can be associated to routine problem; which is solving a well-defined problem based on previous experience. Innovation is rather associated to the creation of new methodology and knowledge to solve a problem in ill-defined context (Anderson et al., 2014), (Tidd and Bessant, 2009). What actually matter in this chapter is innovation and more precisely creativity upstream innovation.

2.1. Creativity from innovation

Innovation is defined as the acceptance and widespread use of a new product, process, or service, conveying the notion of success and perceived value from various economic actors (e.g. customers), as well as being different from existing solutions (Tidd and Bessant, 2009). The two major activities of the innovation process are the idea generation and the idea management (Murah et al., 2013). The idea generation activity, also called, ideation is the creative production of ideas individually or collectively (West and Rickards, 1999). The idea management is the registering, filtering, and evaluation of the ideas in the objective to reuse it. In the perspective to produce ideas, creativity is the ability to look at the problem in a different way and to restructure the wording of the problem in order to make emerge new unseen possibilities (Linsey et al., 2008). Certainly the most accepted definition of creativity is those of adaptive novelty (Perkins, 1994). It means creativity is a balance between concept novelty and usefulness (West and Sacramento, 2012), (Puccio and Cabra, 2012), (Lubart, 2005) or appropriateness(Zeng et al., 2011), (Howard et al., 2008) which is achieved by using existing knowledge (Ogot and Okudan, 2007). Creativity can be seen as the synthesis of new ideas and concepts through the radical restructuration of existing ones (Hsiao and Chou, 2004).

Whatever creativity or innovation, both are influenced at the different levels of complexity (West and Rickards, 1999). They can be perceived as a whole of individual attribute (Sternberg, 2005). Some authors will defend creativity as a value instead of competencies whereas others will consider the opposite (Perkins, 1988). In terms of cognitive sensibility (Lubart, 2001): problem sensibility, capacity to produce quantity of ideas (fluency), ability to change its mental state (flexibility), ability to reorganize its knowledge, ability to handle competitive context, and ability to evaluate. Thus, creativity can be considered as a cognitive competency (processing information), an artifact production, or a social production which can be dependent or independent of the domain (Sternberg, 2005). The same author suggests the theory of investment that characterizes creativity through six independent

aspects: intellectual ability, knowledge, type of thought, personality, motivation, and environment. All these characteristics can be perceived through three perspectives: individual, collective (team) and organizational (Mumford, 2012).

- The individual perspective gather some of the already quoted aspects that are, expertize, motivations and cognitive abilities (Damanpour and Aravind, 2011). This individual aspect can also be decomposed into different systems: the system that triggers creative activity (personality, motivation), the system that conditions creative activity (education, environment), and the resource system of creative activity (knowledge and information related to problem, tools).
- The collective perspective focuses on interaction between individuals who have different characteristic and impact on the team. This perspective deals with cooperation and collaboration. The most well-known phenomenon related to the collaboration are the production blocking, the judgement fear and the social loafing (Warr and O'Neill, 2005), (Ray and Romano Jr, 2013).
- The third perspective is organisational. It concerns fostering creativity through management policy of the organisation. It is related to the diversity, the interrelations and the trust among the actors and the governance, the team work, the collaboration, the permeability and the flexibility of the organisation (Hemlin et al., 2008). It implies to manage the processes, the culture, the communications and the knowledge of the organization (Damanpour and Aravind, 2011).

All these factors constitute a complex system that have overlaps and correlations that lead to the creative phenomenon in certain configurations. As most of the complex systems, Creativity has some simplifications to ease its understanding. In order to further understand the phenomenon of creativity, it has been described through steps. These steps are commonly and abusively considered as process, even if, it is not constituted by activities and results, and does not explicit individuals and equipment involved (Holt and Perry, 2008). The perception of the creative phenomenon evolve from an ex-nihilo vision (Perkins, 1988), to a sequence of toughs and actions that results into a new and adapted production (Lubart, 2001). The firsts descriptions of creativity through steps are Helmholtz-Poincaré-Getzels model (Lubart, 2003) and Wallas model (Ogot and Okudan, 2007) which introduce the notion of incubation and insight. This vision of creativity is a more or less conscious knowledge processing that leads to the unexpected emergence of ideas. This vision of creativity evolves from an individual and partly unconscious phenomenon to a collective, active and interactive perspective. It substitutes incubation and insight to a further active step called ideation. Literature abound of var-

iations of steps that differ according the number of steps and the degree of details (Salerno et al., 2015), (Sawyer, 2012), (Seidel, 2011), (Howard et al., 2008), (Nemiro, 2004). These variations have different origins. The steps of the collective and dynamic vision of creativity arise from six main approaches (Massaro et al., 2012): creative problem solving, lateral thinking, appreciative inquiry, design thinking (re-engineering), synectics and inventive problem solving (TRIZ and similar approaches). Despite the difference intents between these approaches and the specific characteristics of each one, these "creative processes" also have much in common. Based on the review on engineering and psychological "creative processes" by Howard et al. (Howard et al., 2008), it was highlighted that creative processes can be summarized into four common steps: problem analysis, ideation, idea evaluation and implementation/communication. If the "creative process" is active rather than undergone, it requires techniques and tools to guide individuals and team.

2.2. Creative techniques and tools

Even if some individuals are creative mainly due to their education and/or personality, it is not sufficient. A creative person does not imply creative team and organisation. In order to facilitate and supervise interaction, communication, and exchange of ideas, creative technique can be useful.

2.2.1. Creative techniques

Creative techniques aim to help in the production of ideas and by extension assist in the production of solutions to a problem. One of the most well-known creative techniques is certainly brainstorming, which was invented by Alex Osborn (Osborn, 1963). This is part of a wider approach named Creative Problem Solving (CPS) (Osborn, 1963) which provides the framework for the correct application of brainstorming. This framework is a set of rules: deferring judgement, favouring quantity over quality, avoiding any kind of censorship (Osborn, 1963). CPS has become a "creative technology" by combining a collection of creative techniques (Magyari-Beck, 1999). For decades, the number of creative techniques and the resulting literature have constantly increased (e.g. (Martin et al., 2012), (Michalko, 2006), (VanGundy, 2008), (Aznar, 2005)). Despite the large quantity of creative techniques, these are based on more or less strong heuristics that force the use of key processes and mental operations to reshape and reform people's existing knowledge and thus generate ideas (Mumford and Norris, 1999). These heuristics

have been structured into 17 higher order rules which represent different styles of processing knowledge to solve problems (Strzalecki, 2000). The efficiency of these metaheuristics also depends on the progress in the CPS process (Strzalecki, 2000). Since heuristics are the basis for most creative techniques, it means creative strategies and products depend on the creative problem to be solved and the phase in the solving process (Li et al., 2007).

Creative techniques are presented as a way of assisting and supporting the creative process and can appear quite artificial as they force people to have thinking styles. The alternative is to teach creative thinking by experiencing creative problem solving during project-based courses (e.g. (Wang, 2001), (Orono and Ekwaro-Osire, 2006), (Mingshun, 2010)) or following a training course(e.g. (Higuchi et al., 2012), (Basadur et al., 1982)). The aim is to automate the cognitive mechanism that leads to creativity for people for whom it does not come naturally. In other words, training makes automatic the application of the cognitive mechanism associated to the creative methods. Similarly to the exploration of the "design space" induced by TRIZ, that analyses and breaks down the problem and apply solution-orientated rules, the application of creative techniques can also be systematized. At the difference of the TRIZ approach, the CPS and the creative techniques still involve the imagination in the creative process. However, the way creative problem solving is implemented evolves.

2.2.2. Open Innovation changes creative practices

In practice, innovative and creative activities usually concern organisation's strategic level such as the R&D or marketing departments. However, for decades innovation has tended to be broader in the organisation and even open to innovation outside organisations (Getz and Robinson, 2003). This is not a new principle, but its theorization under the term of open innovation (Chesbrough, 2004) is recent. The increasing use of Information and Communication Technologies (ICT) in organisations change the innovation paradigm and creative practices (Adamczyk et al., 2012). A widespread practice permitted by ICT is the innovation contest which is increasingly popular in organisations (Adamczyk et al., 2012). "Innovation contests can generally be described as IT-based and time-limited competitions arranged by an organisation or individual and calling on the general public or a specific target group to make use of their expertise, skills or creativity in order to submit a solution for a particular task previously defined by the organiser who is looking for an innovative solution."(Adamczyk et al., 2012). Such contests can be divided into five categories based on the intention of implementing an innovation contest: economic perspective, management perspective, education focus, innova-

tion focus, sustainability focus (Adamczyk et al., 2012). Depending on a flat or hierarchical governance and a closed or open participation (Pisano and Verganti, 2008), innovation contests are implemented differently. In the case of open participation, innovation contests can also be described as crowdsourcing (Piller and Walcher, 2006). The nature of the input required for participation can vary from the idea to the solution and the nature of the task can vary from open to specific depending on the way the contest is created and the innovation policy (Elerud-Tryde and Hooge, 2014). Various companies from different industrial sectors have experienced innovation contests including Adidas, Salomon, O'Neill, Procter & Gamble, BMW, Volvo, Starbucks, IBM, Dell, Microsoft, Siemens (Piller and Walcher, 2006), (Adamczyk et al., 2012), (Elerud-Tryde and Hooge, 2014). Organisations can also subcontract the management of innovation contests to platforms such as InnoCentive1, OpenIdeo2, Babele3, Desall4 or Atizo5. The innovation contests; which are a form of CPS and their digital tools argue for the non-negligible role of ICT by permitting creative activities and capitalize the results.

Creative practices are tooled in order to simplify their operationalization and increase their potential results. Since decades, works are done to establish various methods and techniques. The next step, implies both the increase of digital devices and virtual team collaboration, is to create digital systems adapted to creative practices. Before talking more precisely about Creative Support Systems, the next section presents, more in detail the creative workshop; which is one of the creative practices, followed by the issues it implies, and some typologies of system.

3. Current challenges of Creative workshops

This section will present an instance of creative workshop and highlight some of the limitations and difficulties when organising and operationalising creativity workshops. The coming statements are not uniquely based on literature but also continuous observation over several years of the "48h to generate ideas" creative workshop. It is an international contest, organised annually in France by the ENSGSI, an Engineering School of the University of Lorraine, since 2001, which proposes a simultaneous creativity workshops with participants from different

[1] Innocentive: http://www.innocentive.com/
[2] OpenIdeo: https://openideo.com/
[3] Babele: https://babele.co/
[4] Desall: http://www.desall.com/
[5] Atizo: https://www.atizo.com/

universities in France and overseas[6]. Participants are mainly undergraduate students from different areas of engineering. The workshop deals with subjects provided by industrialists whereby a number of teams ideally composed by students from various disciplines work using creativity techniques during two days to suggest innovative and original solutions.

The difficulties that have been encountered could be summarised as follows:

- Formalising the problem to be solved,
- Selecting creative techniques which are adapted to the problem and the experience of the participants,
- Reaching the right balance about the time spend on applying creative techniques to get the richest ideas without lead to frustrations,
- Providing the eventually missing information concerning the implementation of the techniques for the facilitator,

Permitting rich exchange between distant teams who work on same subjects. These difficulties are the on-site observations of organising and managing creative workshop. Firstly, in the next sub-section, we will provide more detail about what we mean by creative workshop in order to precise the challenges of managing creative workshop in the second sub-section. Then the prospect of using digital devices will be developed in a third sub-section.

3.1. The basis of a creative workshop

A creative workshop, also known as a creativity session or creative jam, involves bringing together various people (if possible, from different departments or with varying expertise) in order to solve a problem creatively. This creative problem solving consist in applying creative techniques that ease discussion and confrontation of points of view, reduce the latent inhibition (Carson et al., 2003) and almost engage people in thinking styles that they would not naturally use. A creative workshop can be broken down into the four iterative phases presented previously: problem analysis, idea generation, idea evaluation and implementation/communication (Howard et al., 2008). In accordance with these phases, six

[6] In 2015, the number of participants was 1,200 students from 20 schools and universities in 6 countries.

different actors take part in the process (Fig. 1): facilitator, organiser, “ideator”, decision-maker, expert and evaluator.

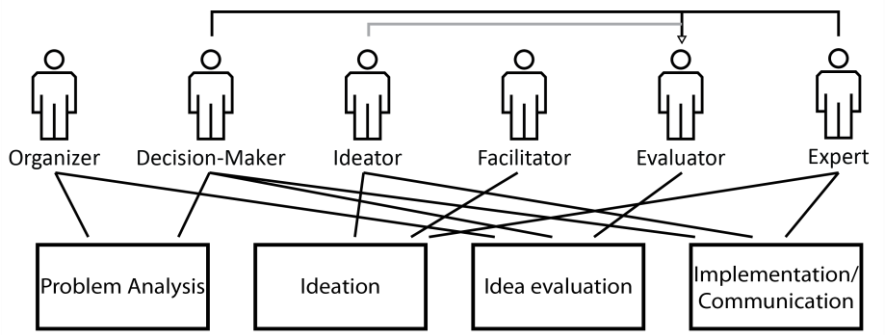

Fig. 1. Simplified representation of the roles involved in the creative phases

- The organiser is responsible for providing the furniture and the environment for the workshop and communicating with the workshop’s different actors. During the problem analysis, the decision-maker discusses the problem to be solved with the organiser, defines the approach to be adopted and the appropriate subject formalisation and the approach for evaluating the product of the creative workshop.
- The decision-maker is the person who has a problem to solve. He is the “project owner” as he provides the problem, the context and the expectation. He is the person who has the final decision to continue the workshop, develop and implement an idea or stop everything.
- The facilitator aims to support the group of “ideators” in the problem solving. This support consists of creating a dynamic and assists the application of creative techniques. He organises the application of creative techniques according to the workshop’s objective, the subject, the participants and the facilitator himself. The facilitator preferably has some knowledge about creative practice.
- “Ideators” solve the problem by suggesting ideas through the application of creative techniques. It is suggested “ideators” differ in terms of background and competences in order to have different points of view and thinking styles.
- The evaluators are people who participate to the evaluation of ideas. They can also have another role as facilitator, expert or decision-maker. The role and how the evaluator works differ depending on the strategy initially defined by the decision-maker but there is at least one evaluator: the decision-maker. The role of evaluator is to apply criteria or provide

feedback about the ideas generated according to his expertise and experience. The role of organiser during this phase is to oversee the exchanges and discussions about the idea. Participants who generate ideas can also have the role of evaluator but the evaluation should be considered according to the participant's expertise and make sure to avoid any conflict of interest.

- Experts may be needed during the ideation phase to advise the "ideators" when there is a lack of competences. They can also participate as evaluators in order to judge of specific aspects of the ideas.

Finally, the implementation/communication phase depends on the products expected from the workshop. The participants may have to produce some prototypes before the ideas are presented and evaluated. The other aspect of the implementation/communication phase is the transfer of the validated ideas to embodiment design by the decision-maker and the evaluators.

The execution of the creative workshop described above is general enough to be set in academic or professional context. Differently to what happens in academic context, in companies the same person could assume different roles. For example, one person could be the organiser and the decision-maker simultaneously, or the organiser could also be facilitator, provided that they have enough experience.

3.2. Creative workshop issues

Various aspects of the creative workshop can be discussed: the collaboration mode, capitalization of information, workshop management especially the development of the process and the assistance of the activities specific to each phase.

A creative workshop is collaborative and cooperative by definition since it aims to use collective creativity to solve a problem in a group. A creative workshop usually involves people that are in the same place. This normal co-located configuration entails some difficulties. In general, the application of creative techniques and the creative workshop generate a large amount of information and knowledge in a short time span. The fact that people are all together is positive in terms of knowledge management because it allows informal discussions between participants but makes capitalization complicated (Gronau et al., 2012). It implies information management challenges. The added value of a creative workshop that matters to be capitalized is the produced number of original ideas. But at the same time, it implies to manage information, such as the problem definition, the context and complementary information to produce it. This information is the first input of

the creative process that permits the application of creative techniques and the production of ideas. One practice for the capitalization of ideas is to complete idea cards in order to keep track of the ideas and their characteristics. This is quite a flexible way to keep track of ideas as it permits annotation, quick changes and the option to draw on it but the processing of the cards is tedious. In terms of the contextualization of ideas, it is limited to the title of the subject.

Another challenge concerns the formulation of the subject and the problem to solve by the "ideators". The subject and the problematic is the prerequisite of the workshop to enable "ideators" to generate ideas in the right way. However, this critical formalization task is supported by any technique or methodology.

Concerning the organisational aspect, a creative workshop can be resource-intensive and inefficient (Mumford and Norris, 1999). The aim of the organisational aspect of a creative workshop is to improve the efficiency and overall experience for all those who are participating. However, many factors influence the success of a creative workshop. The creative techniques aim to produce interesting ideas more quickly but some heuristics inherent in creative techniques are more useful than others depending on the phase in the creative process and the expected creative product (Mumford and Norris, 1999). The increase in efficiency and the decrease in eventual frustration affect the organization of the workshop according to the problem to be solved, the context and the stakeholder's expectation (Herrmann, 2009). In order to improve the efficiency of the creative workshop, the way to design it must be explored to improve the consistency between the various activities involved. This construction of consistency is however limited by several things, notably the facilitator's competence in applying creative methods and how he uses the available resources (whiteboard, sticky notes and other supplies). The limiting factor is the knowledge, the experience and the confidence of the facilitator to apply creative techniques, the resources and the tools available and how he uses it to support creative activities, and finally its ability to create a creative dynamic in the group.

Some of the main challenges of the usual co-located creative workshop mentioned above are: the limitations of the capitalization of ideas, almost impossible to reuse, the lack of problem and context capitalization, the possible lack of consistency between the workshop's activities, the potential optimization of the creative workshop and high dependency on the facilitator's competence. All these limitations are true when actors are in the same location. In the case of remote collaboration (distributed teams), the issues are slightly different.

The use of ICT cannot be avoided when collaborating remotely. The team is divided into smaller teams or individuals. Some existent innovation contest plat-

forms integrate collaboration into the process, such as for example the evaluation of the idea by other participants on OpenIdeo, but it is harder to implement the collective aspect of creativity by applying collective creative techniques in a dispersed context. The necessary use of ICT makes it easier to capitalize the information and especially the ideas but it does not solve the other issue mentioned above. The creative workshop still needs to be designed and this is even more difficult as activities should be adapted to each actor and permit the creation of a creative dynamic. The organisational aspect remains an issue since it is not a single schedule or environment that has to be managed. Related to the organisational aspect, the operational aspect is also an issue. The application of creative techniques requires a suitable interface since digital devices are less flexible than a whiteboard and sticky notes. Moreover, studies have to be carried out on adapting the creative techniques through a digital interface without inhibiting the creative dynamic.

The management of information (ideas, subject, problem…), the design of the creative workshop and the application of the creative techniques are issues for both co-located and remote collaboration. The challenge is to develop these aspects of the creative workshop. The assumption is to design a digital system that would provide assistance and empowerment during the implementation and processing of a creative workshop. The aim is to gain enough intelligence to ease the creation, formalization, capture, evaluation and reuse of the ideas during a creative workshop. In order to reach this sort of intelligence, the adopted approach is this applied in the field of knowledge engineering. It consists of modelling the human activity and identify the competencies and knowledge involved in order to build the adapted system that would reproduce or assist the human activity (Charlet et al., 2000). From a process perspective, the system would aim to nurture creativity during the workshop through the dissemination of adapted knowledge and the use of adapted technology and tools. However, in practical terms, the benefit of digital devices in supporting creativity and its functionalities depends on the collaboration and dispersion settings.

3.3. Assisting a creative workshop with digital systems

The prospect of using digital devices to support creative activities is not original. The idea of computer and artificial intelligence for assisting creativity and Creative Problem Solving has long been present in the field of creativity (Proctor, 1999). From the point of view of creativity research, four classes of creativity support systems were suggested (Lubart, 2005): coach, penpal, nanny and col-

league. The nature of the assistance are respectively: advising and helping on implementing creative activities, providing support for collaboration and communication, monitoring progress, and generating ideas and solutions aside from humans. From the point of view of computer science, another classification of five typologies of computer support programs were suggested (Proctor, 1999): (1) creative problem solving programs, (2) outlining and presentation programs, (3) thesaurus programs, (4) incubation programs and (5) groupware programs. In addition to the various systems classifications, a distinction should be done between programs that are designed for individual use and programs that are designed for use with groups (Proctor, 1999). The individual and collective aspect of the system can be linked to the individual and collective aspect of creativity both of which should be considered in terms of support.

From the different approaches of Creative Support Systems, the assumption is to not prefer one to another. They all provide assistance at different levels of the creative workshop. From the perspective of the creative phases, the CSS would be a combination of the various types of systems adapted at the different phases of creativity as represented by Fig. 2. However, even if the intent is to design a system that integrates the different assistance modes presented above, they cannot all be implemented simultaneously. The priority is to cover the management of the creative workshop that implies managing information and knowledge throughout the different phases of the process. From Lubart's classification, it means advice and support to implement a workshop and monitor its progress. The different collaboration modes will be considered and integrated in this research without being the main focus. Concerning the support for the creative activities and tools in general, the operational perspective will not be addressed. In order to defer the integration of functionalities, the system design has to be modular. In other words, it considers the Creative Support System as a platform which provides high level functionalities like a computer's operating system and modules which provide operational aspects (support for specific techniques) such as computer-aided design software or image-editing software. Based on this position, the next section will present the research done for designing the foundations of the CSS and detail some of its functionalities.

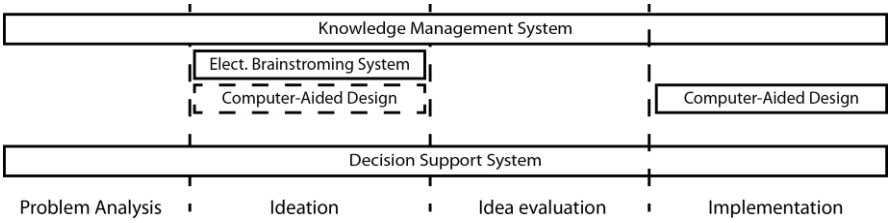

Fig. 2. Type of system that a Creative Support System should combine throughout the creative process to provide extended assistance

4. The prospect of a creative support system for a creative workshop

The current application of a creative workshop, regardless of the collaboration mode, has various prospects for improvement through the use of ICT. However, the idea of using it to improve the creative activity is not new and several experiments have been conducted. Despite a significant number of experiments, some avenues remain particularly promising and yet unexplored. Before presenting these promising avenues and the development of some of its functionalities, the previous experiments on Creative Support Systems have to be reviewed.

4.1. A state of art of current Creative Support System

A review of the systems to support creativity (Gabriel et al., 2016) quoted and presented in the scientific literature provided an unexpected number of system examples. From a set of almost 90 systems encountered in the literature, only 49 systems were considered as having enough documentation to be studied. This review was based on the observation of several criteria: the phases of the creative process supported by the system, the multi-user aspect (individual or collective) of the system, the ability to support remote collaboration (co-located or dispersed) and the technology used. The main results show that half of the 49 systems considered in the study focus mainly on the ideation phase (Fig. 3). Regarding to collaboration, nearly three-quarters of the systems were designed for collaboration with half of them allowing remote collaboration. In terms of use, half of them were designed for individual use and only 10% were able to support both individual and collective uses. Concerning the support technology, the observed trend was the use web-based technology that permits greater flexibility in term of devices to be used. In

other, the creative technique registered as being most used was unsurprisingly brainstorming.

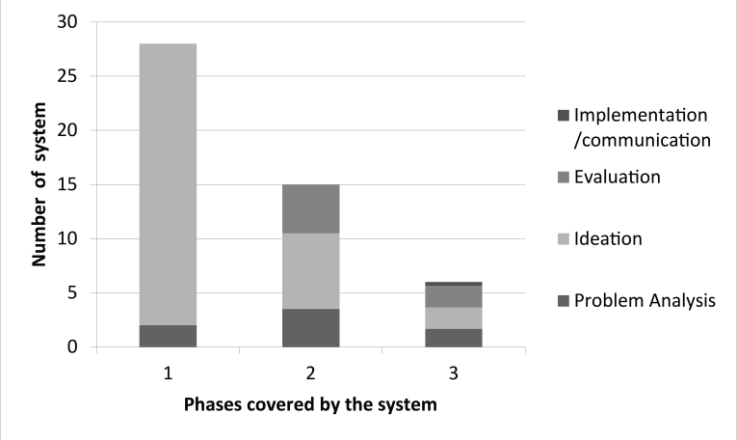

Fig. 3. Steps of the creative process supported by systems that support 1, 2 or 3 phases respectively

An additional finding was the lack of flexibility of the system to respond to the variety of contexts for the application of creative techniques. Few of them support individual and collective uses, even less in co-located and remote collaboration and none of them were able to cover these various collaboration settings throughout the different phases of the creative process. Moreover, in any case, the creative process was described in role and phase-based knowledge-intensive processes. The systems observed in the literature review were not designed to support the different roles throughout the creative process and provide them with suitable knowledge capture and reuse tools. The aim of this work is then, to improve the activities conducted during creative workshops by providing support for decisions made throughout the process. This system needs to support the analysis of the problem to be solved, suggest suitable creative and evaluation techniques, assist in the evaluation of the ideas, provide a suitable interface for applying such techniques and capitalize all the information relating to the problem, the idea generated and the evaluation. In addition, it also needs to individualise this assistance and this knowledge management in every collaboration mode.

In order to respond to these requirements, we decided to explore the field of the Multi-Agent System (MAS). A creative workshop is comprised of iterative steps that nurture each other and should be coordinated by taking into account the needs and the choices of the various actors in the process. A creative workshop as presented above is a complex and dynamic process distributed among the various ac-

tors. These actors are autonomous, but participate in a creative workshop in order to reach a common goal to solve a problem. These parameters are common points for Multi-Agent Systems (Weiß, 1999) which are even stronger in the case of remote collaboration. MAS have applications for decision-making support and computer supported cooperative works which are both aspects of a CSS (Weiß, 1999). Despite this potential and a first presentation of the interest of the agent paradigm in creativity (Boden, 1994), none of the systems reviewed was presented as multi-agent. In order to enable the agents of the system manipulate the knowledge related to the creative workshop; an ontology of the knowledge related to the management of a creative workshop was created. In the perspective of a Multi-Agent System dedicated to creativity, ontology is critical to explicit the shared knowledge among the agents who have to interact(Ling et al., 2007). It provides a standard vocabulary between the system's agents, which makes communication easier. At the same time, it is also an understandable language between agent and humans. Once again, within the review of the CSS, it was found that only one system uses ontologies but mainly for the description of the ideas. The next sub-section details the creation of the MAS model for supporting creative workshop.

4.2. Multi-Agent System for creative workshop

The agent paradigm applied to support creativity is not new. The idea of applying the agent paradigm was first suggested by M. Boden (Ferber, 1999): - the ability to interact with the environment, - to communicate directly with other agents, - has objectives to be satisfied, - has its own resources, - is able to perceive the environment, - represents the environment partially or wholly, - potentially has the capacity to reproduce itself. Without focusing on properties, an agent can be defined as "a computer system situated in some environment and that is capable of autonomous actions in this environment in order to meet its design objectives" (Jennings and Wooldridge, 1998). Based on this definition, a Multi-Agent System is a set of agents cooperating with each other typically by exchanging messages (Bakar and Ghoul, 2011) in order to accomplish a global objective (Isern et al., 2011). "A collaborative design environment can be viewed as a MAS where each agent has knowledge about specific domains and can solve different problems" (Ling et al., 2007). By extension, a creative workshop and its digital support environment can also be considered as a Multi-Agent System. Using agents can notably provide three possibilities: - task assistant for collecting the information and making it easy to achieve the tasks, - consultant for providing the knowledge needed to make a decision, and global assistant for distributing the information to the organ-

isation. The reactive, proactive and flexible properties of the agents justify their use in this context.

The intention to design a system that would support the process across various agents in organisations is enough to justify the use of the agent paradigm (Wagner, 2003). The Multi-Agent System has two benefits: first, modelling and predicting the development of a system as applied in social and human studies (Amblard and Phan, 2006), second, conceiving a system that addresses and anticipates the needs of agents in organisation. In this context, it is the latter which is being considered. In order to design this MAS, there is two different approaches (Girodon et al., 2015): agent-based and organisational-based. In order to support the workshop process, the latter is more adapted as it allows both, the organisation's activity and the knowledge generated, to be represented. In view of an organizational approach, the Design methodology used is based on Organisation, Competence and Knowledge (DOCK) (Girodon et al., 2015). The application of this methodology leads to the formalization of two types of agents:

- The cognitive agents who are based on the human role to better assist their activities.
- The reactive agents who process the information and the data needed by the cognitive agents.

Based on the modelling of the human organization of a creative workshop, the application of the methodology leads to six cognitive agents who monitor the activities of each role in the creative workshop. In terms of reactive agents, the methodology results in the specification of seven reactive agents focused on processing information in accordance to the missions of the agents inside the agents organization that constitute the system. Although it provides the foundations of the MAS by describing the agents that constitute the system through their missions, their competences, their knowledge, their actions, and their responsibilities, it is not sufficient itself to build a system. These agents have also, to communicate, share, process and store information; which means a common vocabulary must be defined. This vocabulary would also permit to structure the system's memory. This vocabulary is defined by an ontology that provides a representation of the area of knowledge of the creative workshop.

4.3. Creative Workshop Management Ontology

First of all, ontology is "an explicit specification of a conceptualization" which is an abstract, simplified view of the world that we wish to represent for some pur-

pose (Gruber, 1993). Although the main objective of ontology is to represent a conceptualization, this representation can have different uses as it permits interoperability or data integration between humans, between humans and machine or even between machines (Bullinger, 2009). In the context of the creative workshops, it would permit the virtual agents to exchange information between each other using a common "language" but also to relate this information process to the virtual agents to those needed by the human agent. It also permits the discovery and the classifications of resources by using ontology as metadata (Héon, 2014).

There are various examples of ontologies for creativity and innovation such as OntoGate (Bullinger, 2009), the Idea Ontology (Riedl et al., 2009), the Generic Idea and Innovation Management Ontology (Gi2MO) (Westerski, 2013), Brainstorming Ontology (Lorenzo et al., 2011), Problem Challenge Ontology (Stankovic, 2010) or even the Context Awareness ontology from the European project idSpace (Sielis et al., 2009a), (Sielis et al., 2009b). However, none of them have an overall point of view of creative workshop. Indeed, some provide a representation of ideas in a perspective of idea management, whereas others describe the concepts of brainstorming. It means some concepts are relevant but after all, it requires the creation of a new ontology to define specific relations. Since ontology is a partial representation of the reality which is dependent on its purpose, the simple aggregation of the ontologies above quoted is not relevant. Due to the necessity to create a new ontology, we adopted an organizational approach to identify the concept of the ontology. This approach consists to model the human activity through their activities, their inputs (resources and knowledge) and their results. This could determine the concepts manipulated throughout the process and know how and when to collect, retrieve and reuse these inputs. Since the ontology's design is combined with the design of a Multi-Agent System, the organisational modelling can be reused form the MAS design process. The resources, knowledge, artefacts and other objects, and concepts illustrated in the creative workshop organisational modelling can be used to define the vocabulary of the ontology. As the aim of the MAS is to assist the creative workshop, the objective of the ontology is to represent the concepts related to the creative workshop and its management. As a result of its objective, the conceived ontology was called Creative Workshop Management Ontology (CWMO) and developed in Web Ontology Language (OWL) with Protégé (Musen, 2015). CWMO will be gradually enriched thanks to its use through the MAS during various creative workshops. However, during the design phase, the ontology creative and evaluation techniques were integrated in order to allow suggestions from the system for the users. The Formalization of the characteristics of the systems' agents, and the formal representation of the area of knowledge of creative workshops, constitutes the foundation of the Multi-Agents Creative Support System. However, the characteristics of the agents do not specify how the ac-

tions should be done and how the knowledge should be processed. So, each agent can be subject to further study in order to define the ability and the intelligence of each one. We arbitrary chose to deepen the ability of the idea evaluation assistant agent. The next sub-section will tackle the ability of this agent.

4.4. Idea evaluation assisted by agent

Even if the design of the MAS provides specifications for the agents, it does not provide them with the "intelligence" needed to carry out their tasks. The difficulty is to understand the dependencies between agents and their distribution throughout the different phases of the creative process. For example, idea evaluation is distributed through the problem analysis, the idea evaluation and potentially the ideation phase. The interest in evaluating the idea is multiple: selecting an idea from a pool of suggestions, managing the creative process (Micaëlli and Fougères, 2007), defining the next step in the creative process, changing the focus of the creative process (Bonnardel, 2006) or even evaluating the performance of the applied creative technique (Oman et al., 2013). The present interest is the selection of ideas from a pool. Choosing one idea from the large number of ideas through creative techniques is a task which implies compromise, judgement and risk (Oman et al., 2013). In order to cope with idea selection, three main techniques are suggested (Westerski, 2013): idea assessment, machine-aided pre-processing, data filtering and clustering. Idea assessment is a task performed by evaluators to enhance ideas in line with the organisation's goal and current needs. Filtering and clustering comprises textual and graphical methods during the idea selection to enhance browsing and searching the idea pool. Finally, machine-aided data pre-processing is a computational task that generates statistics or recognises patterns and pre-processes an idea prior to human assessment. Both the idea assessment and the machine-aided pre-processing have been explored.

An overall process for idea assessment was suggested with four mains activities as represented by the figure 4. The interest of this process is to integrate the context definition into the idea assessment. The context definition ensures consistency between the organisation's goal and the evaluators' preferences. This context definition involves problem assessment, defining a set of criteria and scales, eliciting a criteria's weight and eventually the assignment of the criteria to the evaluator. The problem assessment aims to clarify constraints, expectations and goals. Next, criteria definition attempts to define the criteria and scale depending on the problem and its context. Special attention should be paid to the balance between the number of criteria and the quality of the evaluation. Using overly simple scales leads

to near-random results (Riedl et al., 2010). Then, the weight of the criteria has to be determined. The criteria do not have the same level of relevance from the perspective of the decision-maker and that of the problem. These weights can be either defined expressly by the decision-maker (direct weight elicitation) or elicited from a panel of ideas using the preliminary application of MCDA methods (indirect weight elicitation). Finally, the assignment to evaluators depends on the number of people involved and their competences. Once all the task of the context definition done, the evaluation can be realised by the evaluators followed by the processing of the evaluation thanks to the MCDA method to produce the final score that will be discussed with the decision maker. The second contribution concerning the idea assessment is the formalization of a decisional tree to be integrated into the idea evaluation assistant to determine the multi-criteria decision analysis used to process the score of the ideas for each criterion.

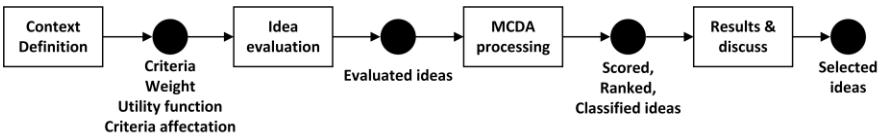

Fig. 4. Overall idea assessment process

In other, regarding the machine-aided pre-processing, the use of semantic analysis was also explored in order to pre-select the ideas that seem to be the most relevant in responding to the problem without being common ideas. The principle was to extract the main concepts from the subject thanks to WordNet and WordNet Domain, do the same for the ideas and compare these concepts. This idea processing should be perceived as a suggestion tool for human evaluation. The semantic analysis, as the context definition and the MCDA selection tree constitute the core of the competences that the evaluation possess to process and generate knowledge. This semantic analysis competence has also some potential for the facilitator and the ideator agents in order to orient the creative workshop process. Several other specifications and functionalities have not been explored but they remain relevant and useful for the success of the future Creative Support System.

4.5. Non investigated specifications

As previously introduced, the Creative Support System aims to better address a creative workshop by collecting information concerning the problem that organisation cannot solve and attempt to solve through a creative workshop. It would be

interesting to classify the problem into typology in the perspective of a creative workshop. There is already a clue to this typology with the classification suggested by Jonassen (Jonassen, 2000) which provides an overall classification of the problem.

Another avenue presented above is the assistance during the application of creative techniques. This avenue implies different perspectives, the adaption of the creative technique to be applied through a digital system for a specific situation, but also the impact of the user interface on the application of techniques. The environment is an influencing factor for creativity, but for remote collaboration, this environment is mainly the interface of the digital devices used between people. The way this interface is designed certainly influences the application of the technique and the productivity.

There is a large amount of creative techniques, each one have to be adapted and experimented to be applied and influenced through a Creative Support System. The best way to deal with the amount of techniques is to consider the Creative Support System as a modular system. This modularity permits to consider creative techniques individually in order to design their digital implementation and their data capitalization according to the collaborative settings. Even if the idea assessment process was formalized, the evaluation techniques can be redesigned according to the collaborative settings. The different ways of applying and collecting the evaluation was not defined from the user interface point of view.

In order to create the entire Creative Support System, further work has to be done on the operational aspect. The actual progress of the research is the overall characteristics through the formalization of the characteristics of the agents. However, technical specifications have been realised as the Creative Workshop Management Ontology which is already developed and some features of the idea evaluation assistant agent.

5. Conclusion

Despite the fact we do not go into detail regarding the system design, the results of this research work are mainly represented by the proposal of a conceptual framework for designing a CSS. The specific feature of this framework is the use of the agent paradigm and the creative workshop organisational modelling. The overall requirements concerning the support for the creative workshop can be summarized as follows: improve the creative workshop strategy based on the capitalization of information about the problem to be solved and the context, help define the crea-

tive strategy; which is composed of the creative techniques used to solve the problem, improve the application of the creative techniques, assist in sorting and selecting the ideas and the capitalization and the reuse of the various knowledge generated by the different actors of the workshop. In theory, the fact of modelling the creative workshop process to design the Creative Support System is a way of reducing its intrusiveness. However, since the system has not been developed and tested, the issue concerning the systematization of creative problem solving without affecting the creative ability of individual remains unanswered.

The perspective of this research is to deepen the mechanics of the agents that make up the creative support Multi-Agent System. However, this development could be based on the competencies, the knowledge and the interactions determined through the organisational modelling approach applied to design the Multi-Agent System. The next step in the development of the Creative Support System is to define how the agents that would assist the different actors of a creative workshop, would carry out their activities and apply these competences.

This work provides an example of the design of a collaborative system that considers the organisational level for designing the support for creativity. The originality of this work is to consider as much as possible the different aspects of supporting creativity in order to finally fulfil the lack of an overall system as observed in the initial review.

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